APR 15 1935

Engineering News-Record

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April 11, 1935

ing the new double-track Pennsylvania Rail-
tunnel at Baltimore with a 36-ft.
eter roof shield riding on walls
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d-driven drifts

MADISON SQ. GARDEN

BYERS WROUGHT IRON WORLD'S CHAMPION ICE RINK PIPING FIGHTS CORROSION

MANY old ice rinks and old refrigeration systems are piped with Byers Genuine Wrought Iron — and what a record it made for itself!

Then, in recent years, came "new ideas" about pipe that had to carry the calcium chloride brine. The New Madison Square Garden is a good example. Some other pipe was substituted for the job wrought iron had done so well for years. The results were typical—failures started in 3 to 4 years and complete replacement was necessary in 8 years, which is the average. Now over 63,000 feet of Byers Genuine Wrought Iron Pipe fights corrosion in the New Madison Square Garden Ice Rink.

Readers of Engineering News Record are great believers in service records and we know from past experience that this typical example will call for the usual deluge of requests for more facts, more details and more service records — and we are ready. Just ask a Byers Engineer or write our Engineering Service Department for a copy of the special report just published on "The Use of Wrought Iron in Refrigeration Systems." It covers not only ice rinks but all kinds of refrigeration systems. A. M. Byers Company, Established 1864. Pittsburgh, Boston, New York, Philadelphia, Washington, Chicago, St. Louis, Houston.

● Photo taken during recent installation of 63,000 feet of Byers Genuine Wrought Iron Pipe for calcium chloride brine lines in New Madison Square Garden.

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"Magna Est Veritas—"

"TRUTH is mighty and will prevail"; thus it was written long ago. And although its progress at times may be all but imperceptible, truth sooner or later becomes so evident that even the most reluctant must respect it.

During the last few days the newspapers have reported some authoritative true talk on the operation of doles, work-relief and emergency public construction in certain cities. In hundreds of other communities experience now is available to those who are willing to observe it and to ponder its significance.

CONSIDER Pittsburgh, for example. Leslie M. Johnston, Director of Public Works, tells a committee investigating relief administration that the mishandling of public works in connection with relief activities has been wasteful and "iniquitous." He recommends that on such construction jobs more general use be made of the contract system whereby the immediate objective would be achieved with a 35 to 50 per cent increase in value to the taxpayers and with a greater impetus to industrial recovery.

In New York City, Park Commissioner Robert Moses, experienced in normal public works construction as well as in work-relief, says:

> *"Let us be frank. It is the deliberate intent back of the work-relief rules to employ as many unskilled men as possible with as little machinery as possible. It cannot be surprising, under these conditions, that work-relief is enormously expensive. In my opinion, based on recent intensive experience as an administrator * * * work-relief costs almost twice what construction work under normal conditions costs."*

Mr. Moses states his conviction that until private industry can absorb more of the unemployed it will be necessary to rely on public construction projects or go to an outright dole. The dole he dismisses as ridiculous. "Federal, state and local officials," he says, "have wisely decided that work, no matter under what conditions, is what the overwhelming majority of self-respecting unemployed want, and what, in the long run, is the only decent and sensible answer."

He believes that meanwhile we must continue to rely on some form of work-relief, admittedly wasteful and inefficient, but offering the only workable compromise between the dole and normal employment.

But even here Mr. Moses insists upon the necessary architects, engineers, draftsmen and field parties to plan and supervise such work, who, he contends, should be hired at reasonable wages even though it might be necessary to find them elsewhere than on the relief rolls. "The slightest reflection," he says, "will indicate to any reasonable, thinking person that the efforts of over 60,000 field workers could not be directed into productive channels by the promotion of relief workers from the ranks."

He tells us also that in his own work he would have experimented with a contract arrangement even for work-relief but was not permitted to do so.

THESE conclusions are confirmed by Colonel William J. Wilgus, the very competent engineer and administrator who was drafted to serve as director of the works division in the New York Emergency Relief Bureau. He reports that among the conditions that prevent his division from achieving higher operating efficiency are his inability to use productive machinery and to handle technical work by contract and, to use his own terms, "the perfectly damnable system of shifts" which breaks up the working periods.

From time to time this page has tried to indicate certain principles that should be observed in our effort to provide public employment that will stimulate rather than obstruct normal recovery. These reputable witnesses who have been working close to the front line attest the soundness of those principles. Their testimony should not be disregarded by those who are formulating and will administer the new emergency construction measure now in Congress.

WITH due respect for these lessons of experience, it should be possible (1) to administer direct relief wherever it may be unavoidable; (2) to carry on by normal procedure an expanded program of public works construction that will foster employment in the professions and related crafts of the organized construction industry, and (3) at the same time establish work-relief policies and procedure that will not serve to perpetuate a thinly disguised dole, scuttle the industries dependent on construction or squander the national resources without a reasonable return in permanent values to the taxpayers.

Willard Chevalier

NRA CODE

ENGINEERING NEWS-RECORD

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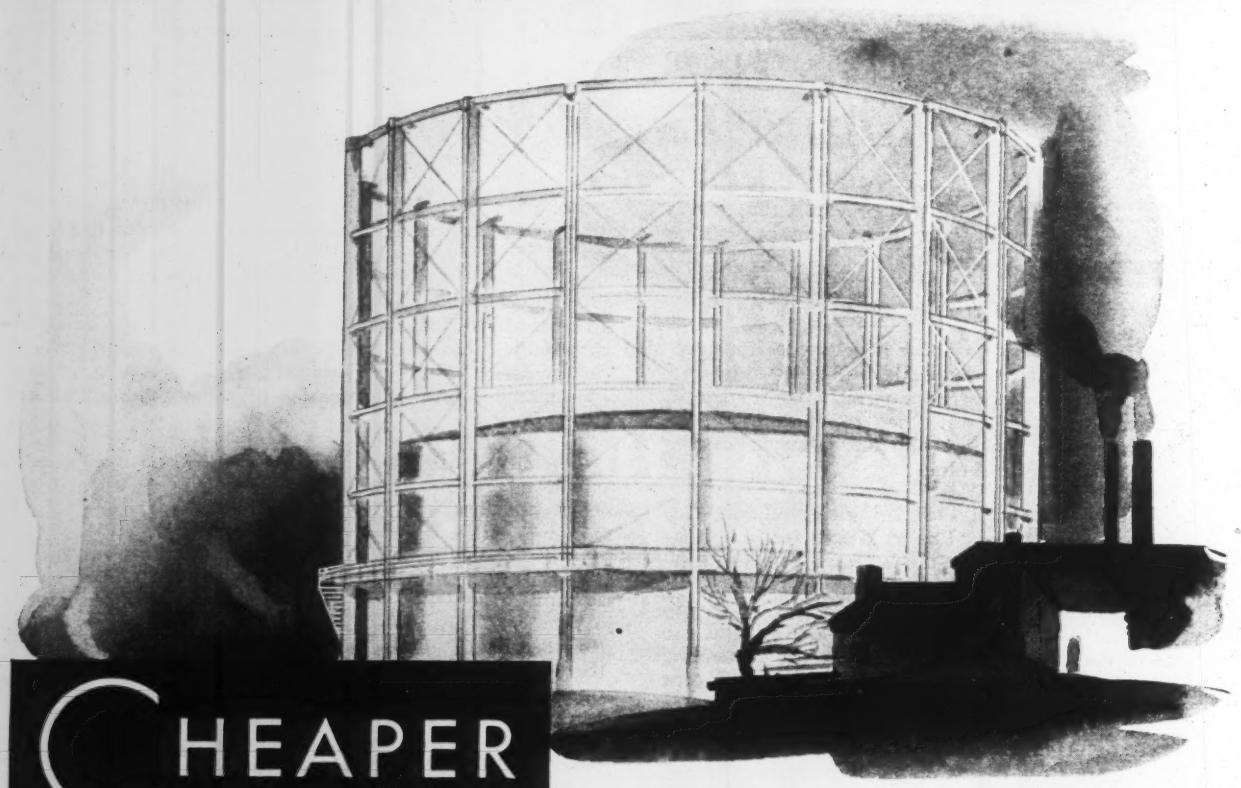
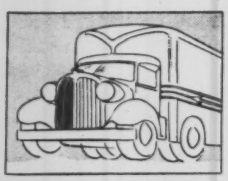
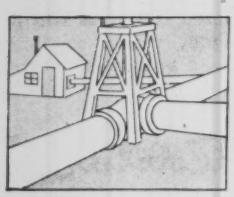
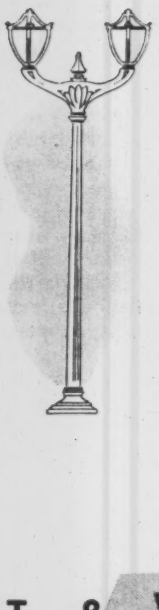


CHEAPER TO PROTECT THAN TO REBUILD!







"LIFE is just one coat of paint after another," says a maintenance engineer. And he is right. Rather, he *was* right. It was a case of paint, paint, paint — or rebuild!

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As is the case of all A & W products, PROTEKTOL has been "tailor-made" for the specific purpose of giving longer life to metal structures and cutting maintenance costs to a new minimum.

So that you may inform yourself as to what extent PROTEKTOL may serve your purpose, you are invited to ask for folder giving details of tests conducted at Ambridge, Pa., showing the relative merits of various coatings when exposed to exceptionally corrosive water. There is no cost or obligation involved.

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In the News:

ELECTRIC OPERATION of all Pennsylvania Railroad passenger trains between New York and Washington began on Monday, the first electric train having been put in service on Feb. 10. Involved are 191 through trains and 448 commuter and local trains. Entering Baltimore, the trains pass through the new tunnel described in this issue.

WORK BEGAN MONDAY on two new 1,000-ft. piers on New York's Hudson River waterfront in lower Manhattan. They will be used by the Eastern Steamship Lines operating between New York and Boston. Meantime superstructure erection is continuing on the 1,100-ft. piers farther uptown in preparation for the French Line's "Normandie" and Cunard-White Star's "Queen Mary."

LARGE-SCALE PRIVATE HOUSING attained headlines last week by virtue of FHA approval of insurance for a $5,500,000 mortgage loan by the New York Life Insurance Co. to a limited-dividend company headed by Joseph P. Day, New York real estate man. The project, to cost $8,000,000, will be on the Gravesend Bay waterfront in Brooklyn.

ANOTHER NOTABLE private capital venture of the week was the purchase by a banking syndicate of $3,100,000 of bonds of the Henry Hudson Parkway Authority, a public body affiliated with the New York City park department. The principal facility to be constructed is a high-level bridge over the Harlem River.

THE IMPENDING SHORTAGE OF POWER reported by the Federal Power Commission last week is characterized as "wishful thinking" by B. F. Weadock, of the Edison Electric Institute. The electric-power industry, says Mr. Weadock, through years of tremendous industrial expansion, has always been able to meet rapidly increasing demands and will be able to meet the demands of future growth.

ON APRIL 8 the President signed the Emergency Relief Appropriation Act of 1935. It provides the sum of $4,880,000,000 for relief and work relief. Large discretionary powers in its administration are vested in the President. The PWA is authorized to continue for two more years and to participate in the administration of the new fund as the President shall direct. Non-federal projects, to be eligible for loans and grants, must be of such a character that at least 25 per cent of the sum goes to wages.

THE PWA reports that more than three-fourths of the 4,040 non-federal projects for which PWA loans and grants totaling $747,757,000 have been made are complete, under construction, or out for bids. Of the total, 1,940 have been completed.

In This Issue:

DRIVING THE NEW TUNNEL at Baltimore for the Pennsylvania Railroad's new electrified line between New York and Washington provided an example of skillful adaptation of tunneling processes in new form to difficult soft-ground conditions. The 36-ft.-diameter roof shield, which rode on walls previously built in small side-drift tunnels, is one of the largest ever used.

BY USING TWO RINGS of well points, the contractor for one of New York's huge new incinerator plants was able to dry up an excavation sufficiently to place a foundation slab 21 ft. below water level.

ROADWAY SLABS may be classified as rigid, flexible and semi-flexible. A review of slab-design theory, with particular reference to semi-flexible bituminous roads, is presented in some detail.

JOHN F. STEVENS' third article recounts the hazardous and exciting experiences of locating the Canadian Pacific Railway west of the Gold Range and across the Columbia River in the early eighties.

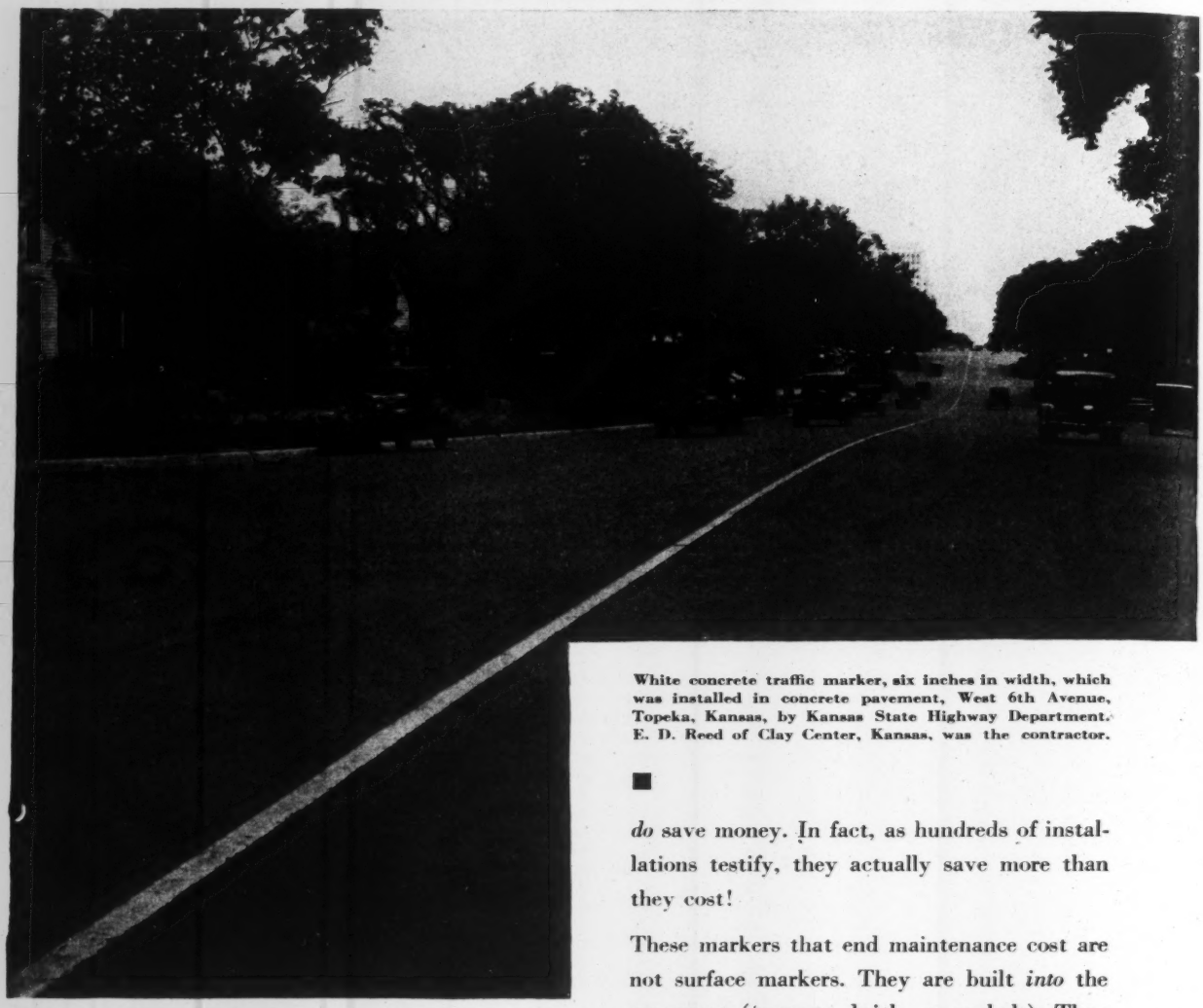
A NEW BUILDING recently completed at the Forest Products Laboratory, Madison, Wis., demonstrates some of the possibilities of modern wood construction. Prefabricated plywood wall and roof units enclose roof arches of several types: a truss with dowel connector joints, a hollow double I-section and a solid rectangular section composed of glued laminations.

STUDIES OF FILTER RUNS made at Chicago have produced a method of calculating efficiency of filtration, which is defined as the ratio of actual output to nominal capacity and utilizes experimental data on filtration rate and length of filter run.

Coming Articles:

TWO ARTICLES scheduled for next week's issue have a particularly broad appeal. In one a proposal to rebuild the Brooklyn Bridge in structural aluminum is outlined. This famous old structure must soon be replaced or extensively repaired, so that the proposal is timely as well as stimulating. In the other article the plant and methods used in placing nearly 650,000 cu.yd. of concrete in seven locks and one dam in the upper Mississippi canalization project are described.

End MARKER MAINTENANCE



White concrete traffic marker, six inches in width, which was installed in concrete pavement, West 6th Avenue, Topeka, Kansas, by Kansas State Highway Department. E. D. Reed of Clay Center, Kansas, was the contractor.

■

SAVING money on maintenance is not the only reason why white concrete traffic markers are installed. But it is the most important.

No matter how good they look, no matter how much time and trouble they save, no matter how much more effective they are, if these permanent white markers did not save money, their installation would be less important. But they *do* save money. In fact, as hundreds of installations testify, they actually save more than they cost!

These markers that end maintenance cost are not surface markers. They are built *into* the pavement (concrete, brick, or asphalt). They are built of solid white concrete. They are finished to a dense, hard, impenetrable white surface. They resist traffic stains and weather stains. No replacement is ever necessary. They *stay* white.

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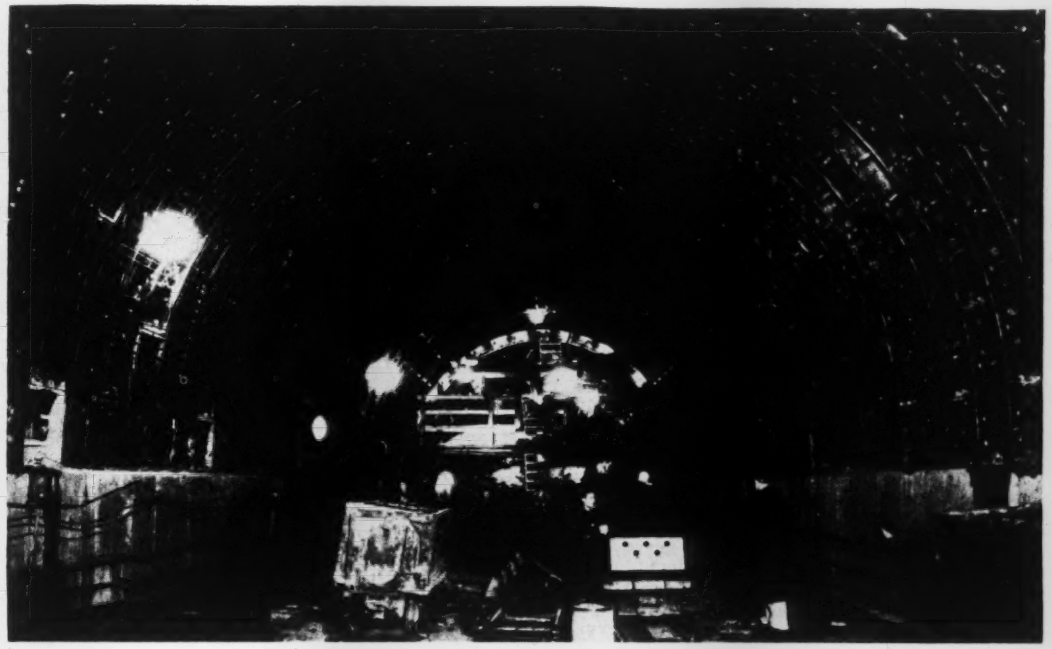


FIG. 1—DRIVING THE NEW TUNNEL for the Pennsylvania Railroad in Baltimore with a 36-ft. diameter roof shield. Cast-iron arch lining was erected on concrete side walls previously built within 11-ft.-diameter shield-driven drifts.

Driving a Difficult Tunnel in Soft Ground

Old Union Tunnel of Pennsylvania R.R. in Baltimore parallelled by new double-track tunnel with cast-iron arch lining built by roof shield running on concrete side walls previously built in small shield-driven drift tunnels

SKILLFUL ADAPTATION of tunneling processes in new form to difficult soft-ground conditions marked the successful completion of a new eastern approach of the Pennsylvania Railroad main line to the Baltimore station during the past year. Construction of this tunnel, begun July 17, 1933, and completed Sept. 19, 1934, was an important part of the preparation for electric operation of the railroad's New York-Washington line, inaugurated early in February of this year. The character of the tunnel problem that the engineers had to solve was, in fact, closely related both to this newest phase of railroad operation and to the early history of the line.

For 60 years the Pennsylvania Railroad entered Baltimore from the east by way of a double-track brick-lined tunnel under Hoffman St., known as the Union Railroad tunnel. Built in 1873, this old structure is 3,403 ft. long between Bond St. on the east and Greenmount Ave. on the west, and consists of a five-ring brick arch, partly with stone masonry footings and partly with four-ring brick invert. All but about 400 ft. of its length had been built by cut-and-cover construction. In the course of time the thin arch had suffered considerable distortion from the pressure of the ground, seriously decreasing the railroad operating clearance.

The brickwork had spalled at many of the joints, and seepage was troublesome at times. For some years its renewal has been in contemplation, and when electrification of the New York-Washington line required increased clearance to accommodate the overhead conductor system supplying current to the trains, it became necessary either to build a new tunnel or to reconstruct the old one. The latter operation, necessarily done under traffic, would

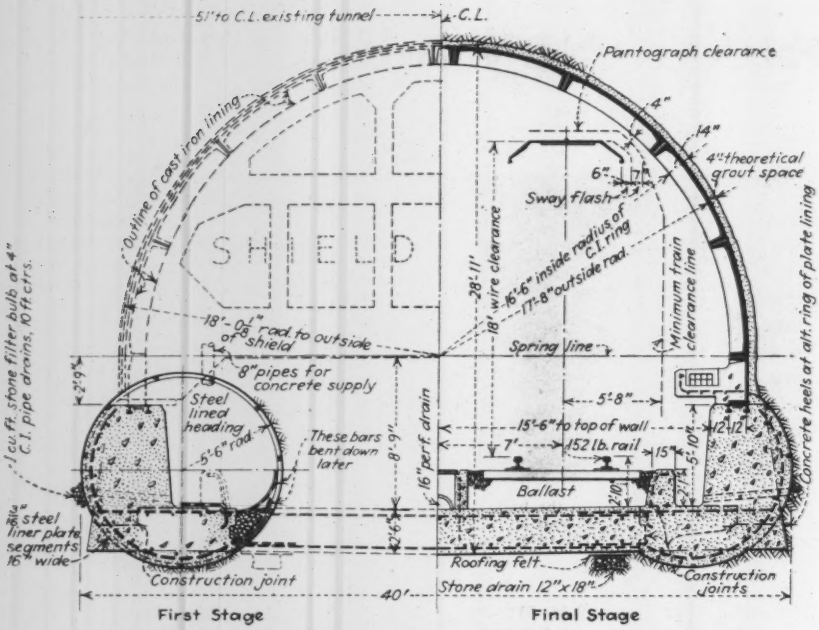


FIG. 2—THE NEW UNION TUNNEL is the largest shield-driven tunnel ever built in mobile ground, and will rank as one of the largest railroad bores in the world. Dimensions and details of design are shown here.

have been extremely difficult and hazardous. In view of this fact and the probability that more than two tracks would soon be required, it was decided to build a new tunnel alongside the old one, and later to refit or reconstruct the old Union Tunnel.

Controlling physical conditions

The available location for the new tunnel was on private property directly south of the old tunnel, which determined the tentative center spacing of old and new tunnels at 51 ft., and left only about 14 ft. between the adjoining walls. The dimensions of the new tunnel are shown in Fig. 2. The cover over the roof ranges from nothing at the portals to about 30 ft. over a length of 1,500 ft.

Essential factors controlling the design and construction of the new work were (1) the shallow cover, (2) the mixed ground through which the tunnel would pass, (3) variable water conditions in the overlying ground, and (4) most important of all, the proximity to the old tunnel. It was imperative that the construction operations should be such as to avoid all movement of ground or change of pressure, so that further distortion of the old tunnel would not be invited. Under these conditions, T. J. Skillman, chief engineer of the Pennsylvania Railroad, commissioned James Forgie, consulting engineer, to devise a tunneling system, plan the tunnel and direct construction operations.

Glacial and stratified materials

The ground at the tunnel location consists of glacial drift overlying gneiss, usually with a layer of soft decomposed gneiss on the hard rock. Wash borings and later test pits showed the characteristic irregularity of glacial formation, with variable strata of sand, gravel, clay, mud, and at the east end what appeared to be a formation of kaolin. Water was irregular, in some places occurring above the level of the tunnel crown, in other places below. It was evident that construction would encounter soil of quite variable stability and treacherousness. However, drainage to a level below subgrade would clearly be necessary in order to make the work secure against risk of ground movement.

Under these conditions it was realized that much of the ground would have to be poled and breasted, and that compressed air could not be used in simplifying or assisting the construction. At the same time the nature of the ground and the depth of the work were such that open-cut excavation through the section of maximum cover was judged to be less safe, considering the proximity and condition of the old tunnel. It remained to develop a tunneling procedure that would assure the utmost security against ground movement and at the same time permit good progress.

Roof-shield method decided on

Since small headings are most secure in respect to holding the face and roof, it was decided that prudence required the side walls to be built first, in separate small drifts, the arch construction to follow. And because of the high degree of safety, shield work was adopted as the means for building the arch, and as later developed, for the side-wall headings. The wall headings, being driven in advance of the main excavation, would give effective drainage, and the completed walls would provide a rigid support for the arch operations.

The same reasons that led to the choice of the roof-shield method also dictated the adoption of cast-iron lining for the arch. It had the great advantage of attaining full strength immediately upon its erection and producing a watertight tunnel—the latter a most desirable factor in operation of the railroad with catenary trolley system, where dryness is imperative.

Two thousand feet of tunnel

The construction program that developed on the basis of this decision permitted building the middle 2,085 ft. of the new tunnel by the tunneling method as described, and sections of 946 ft. at the west end and 295 ft. at the east end by cut-and-cover construction. The dividing line between tunneling and cut-and-cover work at the west end occurred where the rock rapidly began to give place to a preponderance of glacial drift with approximately 20-ft. depth of cover over the roof. The sections of tunnel built in open cut were constructed with concrete arch in place of

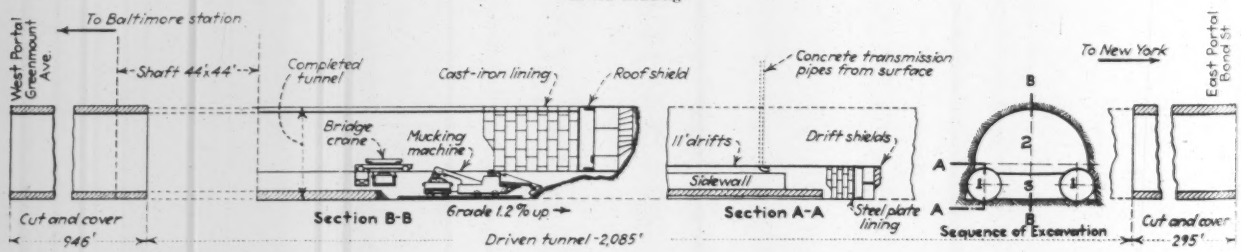


FIG. 3—DIAGRAMMATIC SKETCH of tunneling operations. Side walls, built within 11-ft. shield-driven drifts, later carried a huge roof shield in which cast-iron arch lining was erected. Mucking machine excavated the core between side-wall drifts and loaded out all spoil from the roof-shield heading.

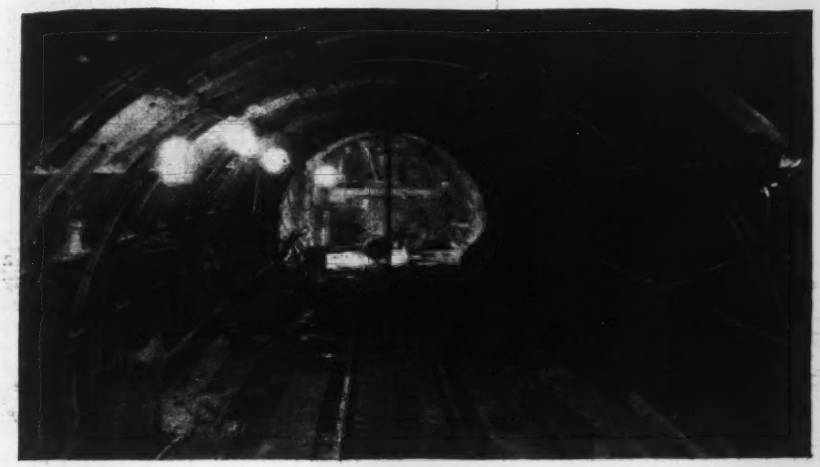


FIG. 4—INTERIOR of one of the 11-ft. steel-lined side drifts. In the background is the shield, still in the rock formation of uncertain cover, encountered at the start and before hydraulic-jack equipment was installed. The vertical pipe strut keeps the roof from collapsing during grouting operations.

cast-iron lining, but to the same inside clearance as the tunneled portion.

More in detail, the tunneling system devised as the basis for these decisions comprised two side-wall drifts preceding the main-tunnel excavation, concrete side walls as low as practicable, the side sections of the tunnel invert built in these drifts, and a roof shield of 36-ft. diameter sliding on the side walls, to take out the main excavation and serve as roof support during the placing of the lining in the tail of the shield. Because of the thorough drainage afforded by the side-wall drifts, the entire core excavation was taken out down to the invert subgrade level in one operation behind the roof shield. Concreting the invert followed as close as practicable behind the shield, grouting platform and mucking equipment, generally within about 75 ft. of the face.

The method of constructing the side-wall drifts then was evolved by progressive study from a simple timbered heading system through several forms of steel liner-plate construction to the ultimately adopted plan of a shield-driven circular tunnel, 11 ft. in diameter, lined with pressed-steel liner plates. Thus the complete operation involved three shields, two for the wall headings and one for the roof.

As economical design required the walls to be located outward of the center line of the circular heading, and the load of the roof shield would therefore be eccentric to the heading, it was considered desirable to assure the stability of the walls under the load of the roof shield by constructing intermittent flat-bottomed footings under the wall. For this purpose, bottom plates were taken out of alternate rings of the drift lining before the wall was concreted, and the exposed ground was excavated to a horizontal footing surface. These small excavations for toe footings were filled with concrete when the wall slabs were poured.

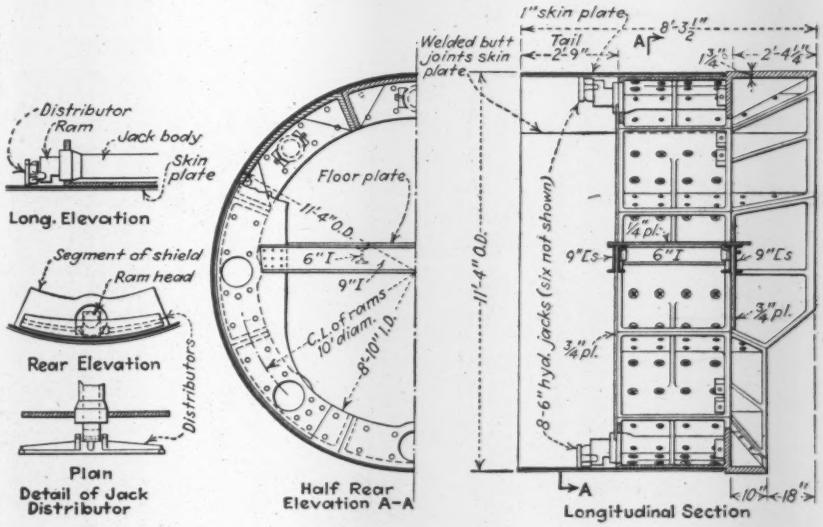
The system of construction thus previously determined was carried out with entire success by the Arundel Corp. of Baltimore, as contractor for the work, under the personal direction of James Forgie and the general supervision of the railroad's engineering department under T. J. Skillman, represented by W. B. Wood.

Dimensions of tunnel

In clear inside dimensions the tunnel is 33 ft. wide (arch diameter inside of lining) and 24½ ft. high; in outside dimensions it is 40 ft. wide by 29 ft. high. It is thus the largest shield-driven construction in this country. The arch above springing line is semicircular; in the 33-in. height from top of side walls to springing line the cast-iron lining is vertical. There is no concrete or other lining inside the cast iron. The invert slab (of concrete) is 30 in. thick. Two longitudinal porous pipe drains under the invert take care of soil water, while internal drainage of the finished structure is provided by a perforated metal drain under ballast between tracks. All drains are connected to a sewer at the west portal. Inside the side walls are two 25-in. curbs, to form a drainage channel along either side and to retain the ballast; drain pipes at 10-ft. spacing lead from the back of the side walls to these drain channels. A cantilevered concrete sidewalk built above each side wall contains ducts for the power cables.

Track consists of 131-lb. rail on wood

FIG. 5—SMALL DRIFT SHIELDS were unusual in design, being built up of cast-iron segments bound by a 1-in. steel skinplate.



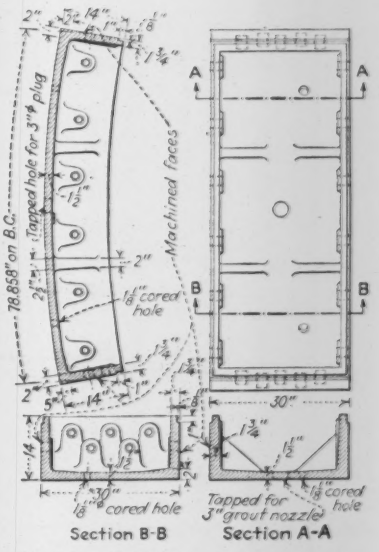


FIG. 6—CAST-IRON roof lining is made up of five types of segments. Details of a standard segment are shown here. Other types are necessary for the keys, key connections and a straight 33-in. length below the springline. Standard segments weigh 2,400 lb. each, and the entire cast-iron arch lining weighs 8,880 lb. per foot of tunnel.

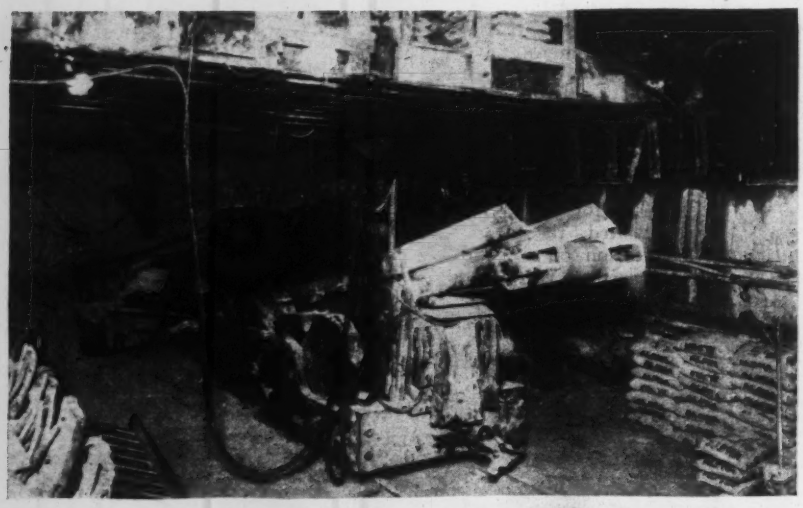


FIG. 7—MUCKING MACHINE that cut out the bench between side drifts down to subgrade level and removed spoil from the roof-shield heading. Muck was loaded onto small cars at subgrade level, and these were transferred to running tracks at the sides by a bridge crane (see Fig. 3). The structure above the mucking machine is the grouting platform, riding on horizontal tierods installed temporarily to prevent flattening of the arch during bolt tightening and grouting operations.

ties on 18 in. of stone ballast. Lighting is by reflector lights 100 ft. apart, high up on the arch on either side and staggered.

The cast-iron lining has flanges 14 in. deep. The rings are 30 in. wide; the segments are machined on their joint faces, and the bolt holes are cored (2 in., for 1¾-in. bolts). Each segment has a 3-in. hole for a grout nipple in place of the usual small grout hole. These large grout holes were provided because originally it was hoped to pump concrete instead of grout. In practice this was not carried out, the old-time grouting methods being used instead.

The cast-iron lining has a 3x1x12-in. steel bond plate bolted to the bottom flange of the lower segments to fit between the rails in the tops of the side walls. This bond was more theoretical than practical, so far as the structure was concerned, but acted as a good check for alignment of the progress of the shield. The plates were set in cement mortar just prior to erection of the lower side segments. The total weight of cast iron in the arch lining is 8,880 lb. per foot of tunnel for a displacement by this cast iron of 22 cu.yd. per lin.-ft.; the displacement of the entire structure was 36 cu.yd. per lin.-ft.

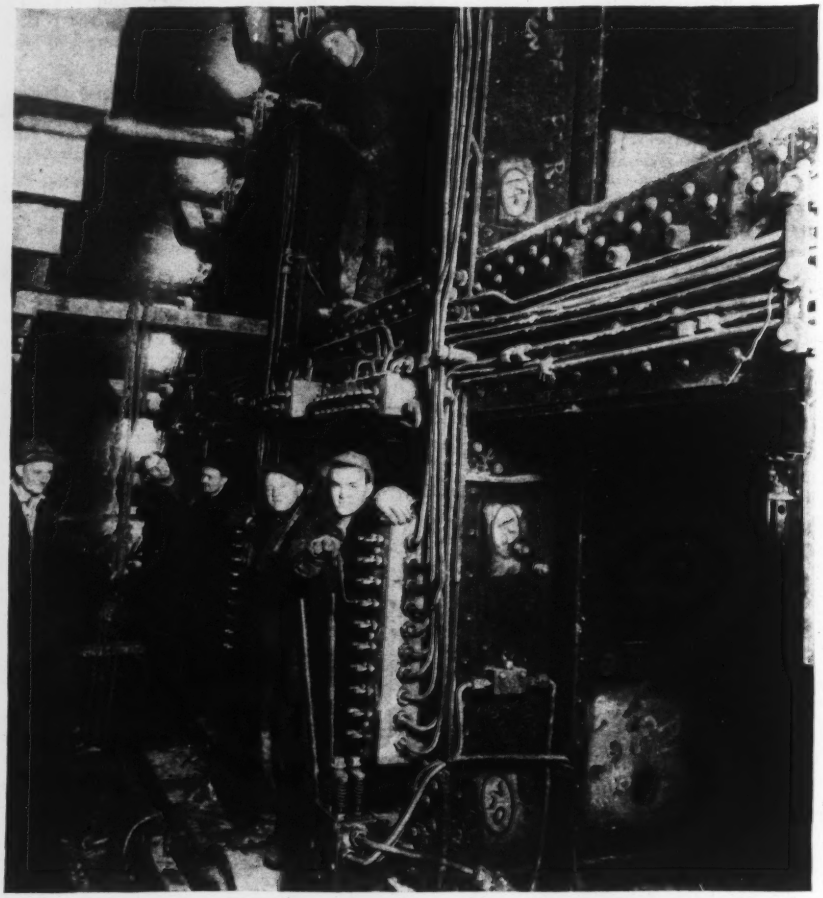
Construction operations

Tunneling was started at the west end of the tunnel section, at which point a shaft was sunk to subgrade level to provide for erection of the shield and removal of excavation before the open-cut section of tunnel had progressed to the beginning of the shield portion. The distinguishing features of the work include the shield and lining of the wall headings, the handling of the face operations, the method of excavating and disposing of spoil and distribution of concrete by a concrete pump placed on the surface and delivering through pipes placed in well holes drilled in advance over the center lines of the wall-heading tunnels.

The shields for the wall drifts were of unusual construction (Fig. 5), being built up of cast-iron segments bolted together and enveloped in a cylindrical 1-in. steel skin plate; they were 11 ft. 4¼ in. in outside diameter, and 8 ft. 3 in. long, including a hood projecting forward 18 in. in the upper half. The 1-in. skin plate of the shield extended backward 23 in. beyond the body of castings to form the tail within which the drift lining was erected. Two sets of horizontal 9-in. channels carrying a steel floor plate provided a working platform. Hydraulic equipment included eight 6-in. jacks, each fitted at the rear end with a wide head to distribute the shoving pressure over the full arc of the steel liner-plate flange. Including 4 tons of hydraulic equipment, each shield weighed 19 tons.

These side-wall shields started in on the west end on Oct. 23, 1933, and holed through at the east end on July 23, 1934. For about 500 ft. they passed

FIG. 8—ROOF SHIELD weighing 223 tons was controlled by banks of valves located on the back of the shield structure. The vertical banks seen in this view control the shoving jacks, some of which can be seen in the upper left corner. The first horizontal bank of valves controls the rams moving the eight shield platforms; the second horizontal bank contains the master valves for both shoving and platform jacks. The erector arm (lower left corner) is controlled by the two levers in the central foreground.



through rock, partly decomposed and partly hard gneiss. For the remaining 1,500 ft. or more they had a full face of glacial drift, consisting at first of firm clay but later of clay with interspersed sand and gravel beds, and at times altogether of sand.

Because of the uncertainty of the surface of the rock, these shields were used in that material, and the excavation was carried on in front of the shields with light shooting, which did little damage to the shields (Fig. 4). In soft material the face was kept fully breasted at all times to prevent loss of ground. The rangers of the breasting were braced through the shield to a cross-timber bearing against the front edge of the lining. Anticipating the worst conditions, the shields were designed for but one ring of steel lining; but in practice two rings were excavated for at one time by the extension of steel poling plates resting on top of the cutting edge. In loose sand the miners often had to work rapidly, driving the plates ahead inch by inch while manipulating the top boards of the breasting.

The steel lining proved to be rather weak for the shield thrust, and accordingly steps were taken to distribute the shoving pressures; in this case by placing wood blocks between the flanges of several rings back of the shield.

To those conversant with tunnel mining and making bottom by the ordinary method of poling, the advantages of using a shield will be apparent. Further, the complete circle of steel liner plate afforded a great comfort in the face of the possibility of drainage of the soil by the many joints of the lining.

In these drifts the face material was brought down by hand; and in the harder material air spades and chisels were used. Cars loaded by hand, operating on a narrow-gage track kept close up to the shield, handled the muck. These same cars brought in liner plates, reinforcing material and similar supplies. Small storage-battery locomotives were used in moving cars.

The lining rings were 16 in. wide. Every ring had grout holes to provide for grouting to fill the voids left behind the tail of the shield. Vertical struts made of trench jacks held the lining in shape during the grouting operations, as there was at times a tendency for the lining to flatten under the grouting pressure (Fig. 4). Generally, these steel drifts showed some distortion but withstood the ground forces well.

The side-wall concrete in these drifts was poured in two stages, the lower being the part of the main invert which lay within the heading, and the second (kept about 50 ft. back) being the side wall itself. Steel panel forms 20 ft. long were used to form the face of the wall sections, while the lining of the drifts served as back forms. Great care was necessary in setting the two inverted rails embedded in the top of the wall to carry the base of the following roof shield.

Each pour of concrete in the drift, for a 20-ft. length, involved placing about 20 cu.yd. of concrete, and this was brought in ready-mixed through a pipe from a concrete pump on the street surface above. Bore holes, which had been put down in advance of the shield and were also used for alignment purposes, accommodated these concrete pipes. The operation of the pumping equipment is described farther on in this article. This system of concrete supply left the headings remarkably free for disposal of excavation and for handling forms and reinforcing steel.

It was required by a clause of the specifications that the wall concrete be poured 30 days before the roof shield came on it, both to give the concrete enough time to set to take the heavy load of the roof shield and to assure thorough drainage of the soil before arch excavation began. The time specified was always exceeded, and more often was 40 days, the heading shields being usually 500 ft. or more ahead of the roof shield.

Progress of the headings was rapid and substantially uninterrupted, after the first period of adjustment of the crews to the work. The average rate of heading advance during the latter half of the work was about 15 ft. per day.

A run occurred in the north heading when it was in dry sand, which brought in about 12 cu.yd. The incident was all the more serious because it was in the heading adjacent to the old tunnel and in the neighborhood of the weakest part of the old structure. The void was immediately filled with grout as thoroughly as possible. The efficacy of this grouting was revealed later when, in the course of excavation under the roof shield, a large block of solid grout was found over the north heading, extending some 8 ft. above its crown to the under side of an upper belt of clay.

Driving the roof shield

As mentioned, the roof shield usually was some 500 ft. behind the heading shields. It was 36 ft. in outside diameter and 20 ft. 9 in. high and of usual design, suitably divided for convenience of working and traveled on inverted rails embedded in the top of the concrete side walls. It is the largest roof shield ever used in loose ground.

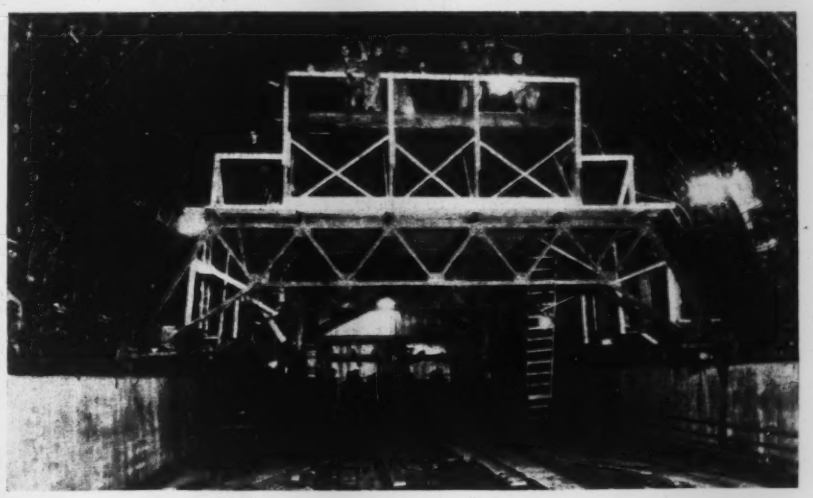


FIG. 9—IN FINISHING the cast-iron roof structure, workmen on a traveling platform gave the bolts a final tightening, calked the joints with lead wire and pointed them with mortar. In the background of the view is the bottom of the construction shaft.

The shield was erected in the shaft late in December, 1933, passed through the sheeting at the west end of the tunneled section on Jan. 15, 1934, and holed through into the junction chamber with the east end concrete tunnel on Sept. 7, 1934.

The shield was of structural steel fitted with a cast-steel cutting edge. The skin consisted of three $\frac{7}{8}$-in. steel plates. Propulsion was provided for by twenty 10-in. hydraulic jacks. Both of the working floors were equipped with sliding platforms moved forward by hydraulic jacks. These platforms as usual supported the vertical soldiers of the face breasting during the shove of the shield, the platform jacks yielding as the shield advanced. Rigid support of the face was of course especially important in this tunnel against ground movement that might have endangered the adjoining old tunnel. The shield, with the hydraulic erector jacks and other hydraulic equipment, weighed 223 tons.

In the advance of the roof shield the top sections of the steel lining of the side-wall headings were removed to clear the shield. The face of the excavation was held by a full set of horizontal breastboards, and excavation proceeded by the usual method of setting

forward the boards progressively downward from the top of the shield. Hay packing was used when necessary to check any running tendency, fill voids, back up the breasting and plug any holes that might leak sand. The ground was in all cases too mobile to permit excavation ahead of the cutting edge, which was shoved into undisturbed ground.

None of the excavated material was handled through the shield itself, but the spoil was allowed to fall into the bottom where, together with the core under the shield between the side walls, it formed a substantial sloping bench that was removed by a belt-loader mucking machine traveling at subgrade level immediately behind the shield. This machine loaded directly into 2-yd. skips on flat cars, which were handled transversely by a bridge crane to the side-heading tracks, whence they proceeded to a gantry crane that deposited the spoil into railroad cars. Prior to completion of the concrete approach section of the tunnel, these skips were handled by way of the working shaft to a hopper at the surface.

As the mucking machine ran at floor level and thus could pass under the roof shield, the operation of mucking involved no interference with the erection of the cast-iron arch lining. Erection of the lining, therefore, proceeded immediately after each shove, as soon as the preceding ring had been fully grouted.

Rock occurred at no time in the roof shield face, but for a short length it occurred in the core between the side-wall headings, when it was necessary to support the soft ground above the rock.

Face Breasting—As above mentioned, except when in quite firm clay a skeleton support was used, the face required full support by breastboarding. Two-inch horizontal boards were used, held by 8x8-in. vertical posts or soldiers, in turn held by the sliding shield platforms. Where very loose material was encountered, additional 1-in. boards were placed radially around the greater part of the sides of the shield face, supporting an area a foot or two wide, close to the cutting edge. The inner edges of these boards were wedged against the 2-in. main breasting, and the spaces between or behind them were closely packed with hay or other packing.

Despite these thorough precautions, some parts of the glacial drift were so loose and running that on May 28, 1934, a top board was forced out of the miner's hands and a large amount of loose material, then estimated at 30 cu.yd. or so, ran into the top pocket of the shield, and there choked itself. The void was at once grouted, some 37 cu.yd. of grout being injected. Nevertheless, three days later the surface of the ground 30 ft. above the top of the tunnel and held up by a stratum of clay caved into a void of about 24-cu.yd. content at the surface. It appears, therefore, that the total loss of ground due to the run was fully 60 cu.yd. This void, near the surface, did not noticeably affect the old tunnel.

FIG. 10—NEW METHOD of placing tunnel concrete is to pump it down from the surface through drilled holes. Here is the pump at ground level, being charged by a transit mixer.

Grouting Behind the Shield — Immediately after a shove of the roof shield was completed, the last-placed ring of lining was grouted. In preparation for this, burlap packing was driven in between the iron segments and the tail of the shield, and held in place by circle boards that were pressed tight against the leading face of the lining by the shield jack. After this was placed, grouting began at the bottom segment and was carried up to the crown.

As already noted, the grout holes had been made unusually large, 3 in. in diameter, which was a new departure designed to permit of pumping fine concrete backfilling behind the lining. As no pump adapted to the conditions was available, this idea had to be abandoned; instead, the grouting was done by an ordinary grouting pan. A special nozzle (Fig. 11), having a curved outlet that could direct the grout stream in any direction desired (usually backward and downward), was principally used for backfilling behind the lower lining segments. A glance at the cross-section will show the necessity of thoroughly stabilizing the geological abutment of the arch, previously interfered with by the side-wall headings and the main shield tail. The usual traveling platform rode on the brackets for horizontal tie rods temporarily placed across the lining to hold its shape, and was dragged along by the shield.

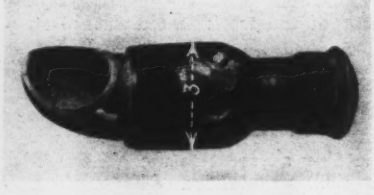


FIG. 11—SPECIAL grouting nozzle, designed for this job, directs the grout stream in any direction desired. The 3-in. threaded section fits into a tapped hole in the cast-iron segment. The curved piece of pipe is welded to the outside shell so that it may be turned from inside the tunnel.

Special care was taken in grouting on the north side, adjacent to the old tunnel. Lower air pressure was used here than on the south side. Though the theoretical void left by the tail of the shield was only about ¾ cu.yd. per lin.-ft., as a rule about three times this amount of grout was forced in. The grout through the upper holes was forced through a pipe extending usually 4 to 8 ft. outside the tunnel lining.

In the erection of the lining the bottom segments were set directly on the rails embedded in the side walls—the same rails on which the shield traveled—with the bond plate fitting between the rails and seated in a bed of mortar. As a ring was completed, a steel tierod with turnbuckle was placed across the horizontal diameter and held the ring in true shape until sufficient succeeding rings had been placed and tightly bolted to prevent any flattening of the arch. Presumably due to the use of these tie-rods, which were left in place until ten to fifteen succeeding rings had been set, and to the care in grouting, settlement of the crown did not exceed ¼ in.

In bolting, hemp grommets that had been soaked in red lead for several days were placed under washers, under both head and nut. The nuts were first run up with air wrenches and completely tightened with hand-ratchet wrenches. Later, in conjunction with the calking, carried on from a traveling gantry platform running on the side-wall rails some distance behind the shield (Fig. 9), the bolts were further tightened by hand, each bolt being gone over three times with long-handled wrenches. The calking grooves in the joints were calked with wire lead by air tools, and finally pointed with cement mortar.

Having regard to stability of ground forces, a considerable ground slope under the shield was maintained as a safeguard against the possibility of a run-in. Concrete for the invert was also carried as close to the shield as conditions would permit, and at the most there was never more than 60 ft. of exposed subgrade behind the shield. The invert subgrade was trimmed, drains were constructed, and reinforcing was placed for a 20-ft. length of concrete floor at a time. Concrete for the invert was distributed from a pipe leading out of the drift heading from the concrete pump to chutes, which spread the mix without much rehandling. Because of the use of this system this invert operation did not interfere with other operations.

Good progress was made throughout the roof-shield work. Toward the end of the job an advance of 15 ft. a day was accomplished. As the excava-

tion, excluding that in the headings, amounted to 28 cu.yd. per lin.-ft., this progress meant something like 420 cu.yd. place measurement, or about 600 cu.yd. loose measurement—some 300 or more 2-yd. skips per 24 hours, or about one skip filled and removed every 5 min. As the mucking machine was always able to keep up with the progress of the shield, and the erection of the iron lining also was completed well ahead of the next shove, it will be seen that the time required to set forward the face timbering controlled the advance. This progress is to be credited not only to the arrangement of operations but also to the praiseworthy application of the men to their work.

Pump handling of concrete

The concrete pump system of supplying concrete to the tunnel was an important factor in the operations and in the rate of progress attained, as already indicated. A pump set up on the surface served the entire work. Concrete was delivered to this pump from the central batching plant by 5-yd. transit mixers (Fig. 10). From the pump, 6-in. transmission pipes made up in 10-ft. lengths with quick-coupling joints extended to one or another of the well-drill holes that led down to the tunnel headings; such holes had been drilled in advance at intervals of 175 to 200 ft. along the length of the tunnel. Within the tunnel a long 90-deg. bend from the pipe leading down through the drill hole connected pipes leading to forms.

The system proved highly satisfactory in operation. The concrete reached the form in a steady stream, and was easily handled even in the restricted working space of the small drifts. There was no interference with excavation work, and the construction track was left free for muck cars. After some initial difficulties in overcoming the clogging of the pipe, the mechanism operated with entire smoothness.

The ingenious method of cleaning the concrete pipe after a pour was used on this job in reverse manner, for the reason that it was objectionable to have water and waste concrete discharged within the tunnel. In the regular cleaning a "go-devil" made of two metal-backed rubber disks fitting the pipe is forced through the pipe by water pressure from the pump end, cleaning out the concrete in front of it. But at Baltimore, after a pour was completed, the go-devil was placed in a short special section of pipe coupled up to the lower or discharge end, this special section terminating in a blank head; the delivery pipe, after being disconnected from the pump, was filled with water from the upper end, and the go-devil was forced up the pipe by compressed air admitted between the blank head and the go-devil at the tunnel end, driving the flushing water before it and cleaning the pipe thoroughly.

At the start of a pour it was necessary to wet the inside of the pipe thoroughly. For this purpose the same procedure as in cleaning the pipe was used to force out the water before beginning concreting, in order to prevent the discharge of water into the tunnel. Also, in order to prevent abstraction of cement paste from the first batch of concrete by its retention on the wall of the pipe, the concreting operation was started by placing the go-devil in the pipe at the pump end, backing this up with 2 ft. or so of mortar, placing a plug of excelsior back of this mortar, and then starting the discharge of concrete from the pump. Thus the concrete was preceded by a plug of mortar, which left a coating on the inside of the pipe and effectively lubricated the pipe for the passage of the concrete without taking any mortar from the concrete itself. Until this expedient was developed, there was always danger of the pipe plugging up when starting operations, through drying out of the forward part of the concrete batch.

D. A. Leisher was resident engineer for the Pennsylvania Railroad. For the Arundel Corp., the work was handled by J. V. Hogan, president, Charles W. Black, chief engineer, and Harry Redwood, tunnel superintendent. The hydraulic-shield equipment was designed and installed by the Watson-Stillman Co., New York.

So far as records of cost indicate, there is good reason to conclude that the shield-driven tunnel cost no more, and probably less, than would cut-and-cover, notwithstanding the fact that the greatest depth to subgrade did not exceed 60 ft.

Well Points Dry Up Wet Excavation for New York Incinerator Plant

THE CONSTRUCTION of a new 750-ton destructor plant at 215th St. and 9th Ave., New York, N. Y., rated as the largest in the world, required excavating for a deep receiving bin in a troublesome water-bearing fine sand formation. The bin, 20x151 ft. in plan, with reinforced-concrete walls and floor slab, was built in a trench 29 ft. deep below general excavation level for the plant, with the bottom 21 ft. below the water table. Though the destructor plant covers a large area, the receiving bin is the only unit that required deep excavation. The entire plant, including the bin, is founded on cast-in-place concrete piles.

The nature of the wet sand material required draining the water out of it prior to excavation if a dry bottom was to be reached. From previous experience with this particular material, the contractor knew that the ordinary methods of draining the pit by shallow sumps as excavation progressed would be futile, for as long as the material was saturated it would boil up from below. Therefore, he elected to lower the water level by a system of well points and to build the bin inside a well-braced sheet steel-pile cofferdam.

Prior to start of work on the bin pit, the entire plant site was excavated to El. +8 (water level El. 0). Excavation for the bin commenced with an 8-ft. shovel cut, 82x185 ft., carried to water level. This provided a wide berm or bench around the bin site on which the crane driving the sheetpiling operated. The sides of this cut were sloped and required no sheeting.

The next step was to install a series of well points around all four sides of the proposed trench, outside the line of future sheeting. Points were spaced at 3-ft. intervals along the sides and at

FIG. 1—WELL POINTS around receiving-bin pit of New York incinerator dry up a troublesome wet hole. This view shows points installed after second shovel cut. The hole was sheeted from this level down.

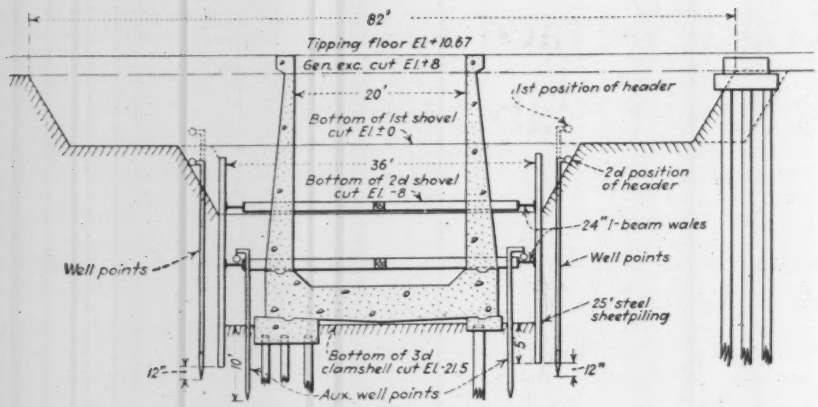


FIG. 2—SECTION OF BIN PIT, showing successive steps in excavation. Well points were installed around outside of pit prior to driving sheeting. Additional points were placed inside the cofferdam as excavation neared the bottom.

6-ft. intervals across the ends. Two pumps were hooked into the 8-in. pipe header circuit. The point units were 25 ft. long, made up of a 1½-in. pipe 22 ft. long with a 3-ft. screened point at the lower end.

This system of well points lowered the water sufficiently to permit another 8-ft. shovel cut, this one confined to the limits of the sheeting lines. Sides of this cut were also sloped, to reduce the pressures at the top of the cofferdam (Fig. 2).

The pit was now ready for the sheeting. Arch-web sheets 25 ft. long were driven by a steam crane rig and braced by a horizontal set of timbering, with 24-in. I-beam wales placed on the bottom of the cut. The sheeting was driven 5 ft. below the bottom of the future trench. After the sheeting was in place and braced, the well points were jetted down about 3 ft. farther, lowering the header lines onto the side slopes of the last shovel cut. This placed the tips of points about 1 ft. below the bottom of the sheeting.

Excavation was continued from the bottom of the last shovel cut by a clamshell handled by a steam crane. After 6 ft. of additional depth had been obtained by this method, another set of bracing was installed. As excavation progressed downward, the first installation of well points proved inadequate to keep the ground dry. This trouble was overcome by installing another set of well points inside the sheeting, jetting the units down to 5 ft. below the bottom of the sheeting. These points, spaced at 6-ft. intervals, connected to header lines laid on the bottom wales of the bracing system. They were served by a single pump placed on timbers spanning between two of the lower rangers. This additional well-point capacity proved ample to permit carrying the excavation down to El. —21.5, just below the bottom of the bin-floor slab.

Driving of the foundation piles, to carry the bin, was accomplished by a skid rig carried on long steel beams spanning the trench and blocked up on the berm of the first shovel cut. As the bottom of the trench was kept dry by the well points, no trouble was experienced in pouring the concrete pile caps, or in the construction of the floor slab.

Well points of new design

The well points used on this job are of a new design (Complete Machinery & Equipment Co. system). Their chief departure from other designs is a fluted sleeve inside an octagonal bronze-gauze and perforated brass-pipe covering. The fluted sleeve is sealed at the top, forcing the water to travel down the outside of the sleeve to the point before it can enter the pipe. A ball valve on the tip is used for jetting purposes, and seals the bottom of the point when the point is in suction. These new-type points are self-jetting and do not require driving.

The new destructor plant was built for the New York City department of sanitation by O'Driscoll & Grove, Inc., New York contractor.

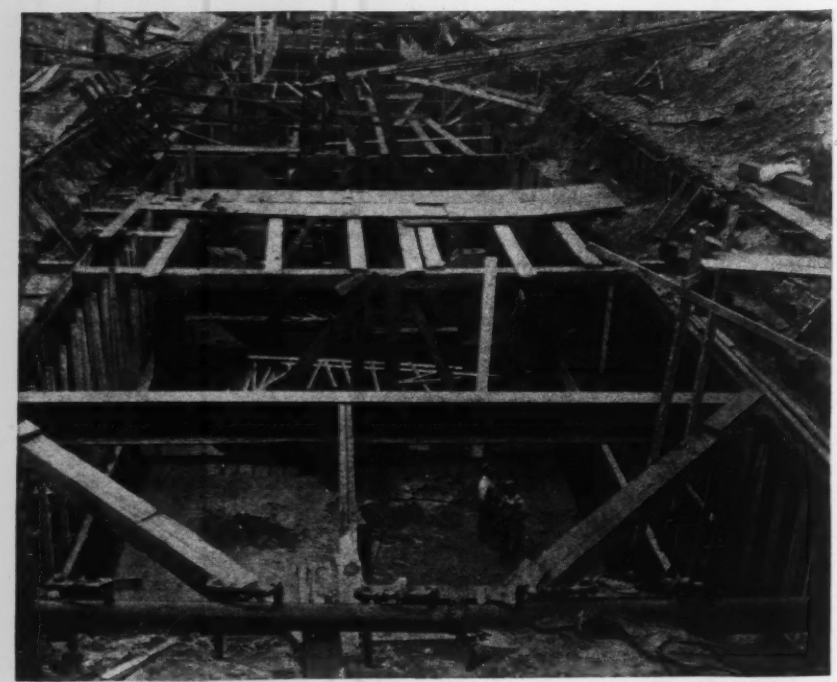


Fig. 3—SETTING STEEL and building forms for the floor slab on a dry bottom of sand 21 ft. below former water level. The header of the auxiliary well-point system placed inside the cofferdam runs along the right wall.

Soil Erosion Work Centered In Department of Agriculture

To unify all soil-erosion control activities of the federal government, Secretary of Agriculture Wallace has issued an order establishing a separate soil-erosion unit in the Department of Agriculture. The base of the new organization will be the Soil Erosion Service, which has just been transferred to the Department of Agriculture from the Department of the Interior. All investigational, service, and control projects on erosion, heretofore handled by the Bureaus of Chemistry and Soils, Agricultural Engineering and Plant Industry and the supervision of CCC erosion-control work now under direction of the Forest Service, have been transferred to the new unit.

H. H. Bennett will head the consolidated activities. Mr. Bennett has been in charge of the Soil Erosion Service since it was organized, and previously was in charge of soil-erosion investigations of the Bureau of Chemistry and Soils.

Semi-Flexible Road Surfaces as Dynamically Rigid Slabs

Combining the advantages of both the rigid slab and the flexible surface, semi-flexible design utilizes both the beam-stress distributing action of the former and the subgrade support of the latter

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THE low-cost road is definitely with us. This is partly the result of the completion of a large percentage of the main-line routes requiring the so-called higher types of paving but is primarily due to the realization that roads should be built to suit traffic. Very few roads which properly require high-type surfacing, on the basis of the traffic using the highway and the income produced by this traffic, now lack such surfacing.

With surfacing design now predicated on construction to suit the available income (backed by observation that certain extremely simple types have given surprising service), an analysis of the possible types in common use seems desirable. In the following the writer makes such an analysis with a view towards more rational design, and with no claim that the principles expounded or the conclusions drawn are original.

General statement

All road surfaces are essentially structures. They carry loads—that is, resist (to a certain limit) stresses resulting from the traffic carried. This is true whether the road surface is merely the natural soil or is a designed surfacing. However, in the usual case the road is a definite structural entity. It can be divided into the surfacing and the subgrade. The surfacing (generally consisting of two components, a mineral aggregate and a cementing medium) is structurally defined as that portion of the road distributing the load to the subgrade, and so reducing the intensity of applied stress that the subgrade is able to carry the transmitted load without failure. This definition eliminates from the present discussion those types of surfaces that merely act as a wear coat on a base course, which performs the load-distribution function.

The fundamental types of surfacing now in common use (with the elimination of wear-course types) are three: (1) the rigid slab, with the portland cement concrete highway as a typical example; (2) the flexible surface, of which the common type is the gravel road treated with bituminous material, clay or other binding material, to hold the aggregate in place; and (3) the semi-flexible surface, or "dynamically rigid type," of which many bituminous mats are examples. This distinction between the flexible and semi-flexible types (previously classed as one) is new, in the writer's belief, but it is an important one, as later discussion will indicate.

We will now discuss the various types purely from the structural standpoint; that is, the comparison of the three types designed to meet the requirements with relatively the same factor of safety.

Rigid slab

A rigid slab is a surfacing in which the combined aggregate and cement form an elastic beam, which is structurally a unit. To fulfill this requirement, the cement must end or act as a solid material. The design of rigid slabs is based on certain theories or assumptions. Since the slab is laid on a uniform subgrade, the supposition would be that it could be structurally designed as a beam with a concentrated loading resisted by a uniform reaction. Actually the uniform subgrade, if obtained, is not easily maintained, as uneven settlement may occur. Expansion or contraction of the subgrade material may occur due to moisture content changes, or the slab itself may change its subgrade contact condition due to deflections resulting from unequal temperature changes.

Design in practice must provide for actual conditions. Experience has shown that the slab corners are the most likely point of failure; and the basis of the design formula is a cantilever beam ("Concrete Road Design," Portland Cement Association Bulletin), with no provision for difference in subgrade bearing power, it being assumed that the average distributed load is below this limit. The effective slab thickness is:

$$d = \sqrt{\frac{1.92W}{f}} \qquad (1)$$

where W is the maximum wheel load and f is the modulus of rupture of the concrete. In such design allowance is made for fatigue stresses, and the design formula is rational; yet due to the subgrade bearing contact uncertainties and other factors, it is in the final analysis empirical in nature, representing satisfactory experience in use. Careful consideration will show that the soil-bearing power must be ignored, and no allowance should be made for direct transmission of a portion of the load to the subgrade at the point of load application. It is apparent that the greater the soil-bearing power the less probable is the uniformity of subgrade contact, as there is less possibility of subgrade-adjusting movement after unequal settlement or heaving.

Considering the material requirements, the particles should primarily possess resistance to crushing or abrasion. The grading is very important, not for stability but to produce a dense strong slab and to conserve cement. The properties of the cement after setting are the important ones structurally, and are essentially the necessary compressive and tensile strength demanded by the beam stresses in the slab. Both of these properties can be tested directly; and once the design formula is adopted, along with the loads to be used, the material requirements can be easily set. Evidently the control of the material properties is inherently more accurate than the design premise on which the formula is based.

The advantages and disadvantages, from a structural viewpoint, of this type of surfacing are rather definite. With design established by experience sufficient to cover the usual range of traffic and subgrade variation, the construction is positive and subject to definite control. In other words, a positive structural unit is obtained which, when made to the above requirements, can be counted on to function and to remain in its original form. At the same time when the discontinuity in subgrade support becomes greater than is provided for by the design, this may be a disadvantage, since failure with necessity for reconstruction may occur. There is no possibility for proper utilization of the inherent subgrade bearing power; frequently excessive overdesign occurs, considering the loads and the soil. Even where no failures appear, curling or a permanent set in the slab may cause roughness and loss of riding comfort. Finally, as in all rigid structures of great length, temperature stresses and expansion problems are always a source of difficulty and in spite of expansion joints, buckling has occasionally occurred.

Flexible surfacing

A surfacing of this type is a combination of an aggregate and a cementing medium to form a structure in which the particles act as units, the cement merely being present to keep the particles in place. In such a surfacing the particles are relatively free to move, the only resistance to such movement and to heavy stresses transmitted to the surfacing being from compressive and

frictional resistance between individual particles. From the definition the cementing medium must remain liquid or plastic. The usual gravel road with bituminous treatment, or water-bound macadam or sand-clay roads (provided the moisture content on the latter is held within reasonable limits) are typical examples of this type.

While the highway engineer has not, except perhaps recently, thought of such types as being susceptible to design, they really are, and in a very simple and logical manner. Such a surfacing adjusts itself to the subgrade, and by its very nature will always be in contact with it. The load applied to the surfacing is transmitted entirely through compression, though distributed over an increasing area as it is transmitted downward by the frictional or interlocking effect of the aggregate particles. The final distributed load is carried by the subgrade, and design must provide that the intensity of this distributed stress be less than the subgrade power. Evidently only compression and shear are involved in the transmission of this primary load, the cement playing no part. The conclusion of investigators is that for aggregates of reasonable stability there is a cone of stress, with distribution occurring at about a 45-deg. angle ("Design and Construction of Bituminous Pavements," by P. E. Gray, presented before the Highway Engineers and Commissioners of Michigan, April, 1934). Assuming either a concentrated load or a load applied over a small area, we can calculate the necessary thickness of surface by using a simple formula

$$d = 0.564\sqrt{\frac{W}{S}} - e \qquad (2)$$

where W is the wheel load, S is the subgrade bearing power, and e is the radius of circle over which wheel load is uniformly applied.

While the cementing medium in this type does not directly function in resisting the primary load, it is very important for a number of reasons. It must hold the aggregate in place against secondary or incidental stresses such as the suction of tires, which would otherwise tear the road up. It holds down dust and assures the maintenance of the structure as a whole, although not interfering with its ability to adjust itself to the subgrade and therefore transmit the load directly to the subgrade without beam action. Evidently the greater the bonding power (or tensile strength) of the cement the greater is its ability to resist such indirect stresses and to maintain the road in its capacity to function. This type of road quite possibly may give very satisfactory results with a cement of mediocre bonding power and life; in fact it may be equal to similar construction with cements of greater tensile strength. The success of this type of road is thus no proof of the merits of the cementing material for uses placing greater requirements on it. On the other hand, obviously the material possessing the greatest tensile strength or cementitiousness is desirable from the structural standpoint to provide the greatest factor of safety for resistance to indirect stresses.

The aggregate, to perform the primary stress function, must have crushing strength, resistance to abrasion and stability. The merits of grading, so far as this load function is concerned, are therefore dependent upon the effect of such grading on stability. In considering stability it is very evident that while the 45-deg. angle of cone assumpton for usual aggregates may be quite satisfactory for empirical design, this angle of distribution is a function of the stability and may vary. In general, since the subgrade bearing power, aggregate stability and loading can be determined with reasonable accuracy (with no highly uncertain factor such as area of subgrade support), the design of this type should be as rational and as safe as the theoretically more accurate rigid slabs.

Considering the merits of this type, in addition to the economic ones which we are not here considering, it has the advantage that it uses the most easily obtained material. A wide variety of aggregates in a wide variety of combinations make suitable surfaces of this type. With relatively low demands on the cementing material, practically any of those commonly used may be suitable if they are fitted for the construction type adopted, although, as pointed out, the higher-type material gives far greater assurance of successful functioning in service. The design is structurally simple and positive, as well as easy to construct. The available subgrade bearing power is utilized due to the ability of the surface to adapt itself to the subgrade. The same adaptability also permits the use of minimum thicknesses of surfacing, with later additional construction in the sections which have shown the necessity for increased thickness.

Against these advantages is the tendency of the type to require a rapidly increasing thickness as the subgrade bearing power diminishes, so that it may become uneconomical for heavy loads on low-bearing subgrades as compared with the semi-flexible type next discussed. It also suffers the disadvantage that the surfacing does not form a positive structural unit as with the rigid slab, and the individual aggregate particles may be removed if the cementing material does not possess sufficient strength to hold them against unusual indirect stresses.

The greater majority of road mileage now being built is of this type, due to its economic advantages, and to the lack of general realization of the possibilities of the semi-flexible type or ability to specify the requirement for that type.

Semi-flexible surface

In the semi-flexible surfacing the aggregate combined with the cement forms a structure in which the aggregate particles are free to move under displacement forces of sufficient magnitude, but with such movement setting up appreciable resistance, including tensile stresses. An indirect requirement of this type is that the cementing material remain liquid or plastic. The usual construction exemplifying this surfacing type is the bituminous mat, with aggregate of high stability and usually low voids. The bituminous cementing material must be of high quality, possessing characteristics that assure functioning according to the intended design.

In this type a portion of the load is transmitted to the subgrade through compression, distributed over an increased area by the frictional or interlocking effect of the aggregate particles. In other words we have the same cone of stress distribution as with the flexible type and the same adjustment to the subgrade of the surfacing since it is free to yield and is flexible in nature. In this portion of the load transmission only compression and shear are involved, with the cement playing no part in the handling of the primary stresses.

Any load which is greater than the ability of the subgrade to handle by direct reaction as above, is supported by beam action of a dynamic type. Evidently if the subgrade resistance, or yield point, is not approached under the cone of direct compression, the load will be supported, and no movement beyond the elasticity of the subgrade will occur. As the yield point under direct compression is approached, the surface will tend to deflect further than the amount due to elasticity. In other words, there will be a tendency for the subgrade material to flow. Both the elastic deflection and this further yield will, however, set up resisting forces that will carry the load up to the point provided for by the design.

While probably not new in stress analysis, this type of resistance does not seem to have been generally applied to highway design, and a short explanation to clarify what is meant will be attempted. In a simple beam certain stresses are set up by the beam action. The beam deflection causes vertical and horizontal shearing stresses that are transmitted by the resistance of the material (in this case by the friction and interlocking of the aggregate). Such horizontal shear develops compression in the upper half and tension in the lower half of the beam. Both these stresses are resisted by the material. In a dynamically rigid beam (for lack of a better term) which we are discussing, the compression will be re-

sisted by the aggregate stability. In the lower portion the tension will be resisted either by the cementing material acting as an elastic medium in the form of extremely thin films at the points of contact between the aggregate particles, or through the resistance set up by the movement. In other words if the tensile strength of the cementing medium is not exceeded, the material will either act as though elastic, or the phenomenon of ductile yielding will occur. In the latter case flow will start, resistance to this flow will be present, and as long as this resistance is sustained the required tensile stresses will be built up. For this interval then the surfacing will act as a beam, and will support a certain load.

Evidence supplied by observation indicates that high-quality bituminous material, in films of the proper thickness on densely graded aggregate—that is, aggregate with numerous points of contact—shows an action equivalent to elastic properties, due to this "thin film effect."

(While, as later emphasized, the correctness of this film action theory is not essential to any conclusions reached in this article, and the subject is therefore not elaborated on, the writer believes this is the first reference in the literature to this extremely important concept. It is particularly important at present in connection with the classification of asphalts into rapid, medium and slow-curing. The distinct "setting up" of some slow-curing products, usually of high tensile strength, should be attributed to this action instead of absorption or similar removal of non-asphaltic components.)

Such surfacings will then show beam action up to the bitumen yield point, similar to a rigid slab; yet due to the lack of static resistance of the material, a slow adjustment tends to occur under continuously applied load, so that continuity of subgrade support prevails in practice. However, this thin-film effect need not exist in theory or in fact for the surfacing to function as described, provided the load dynamically carried is not too long applied. Since calculated load stresses imply impact allowance, which will not be present if the vehicle stops (and only a static load must then be contended with), we will not usually have static failure of such surfacing. Subgrades applicable to this type will have sufficient actual supporting power to handle such statically applied loads through direct compression. In other words, the success of this type is its combination of direct compressive resistance, plus what is essentially a flow resistance. The most outstanding requirement of this surfacing is the definite need for tensile strength in the cement. As long as this is not exceeded, ductile flow rather than rupture will result.

(There is a special case where the consistency of the cement will also be of importance, directly as well as indirectly, in connection with the ductile-flow characteristics. This is where an aggregate lacking inherent stability is used with a cementing medium of high consistency; and the shearing stresses, instead of being transmitted by the stability of the aggregate, are transmitted by the resistance to flow of the cementing medium between the particles.)

In order to get maximum stability and points of contact between the particles, it has been emphasized that the aggregate should interlock and should be densely graded. However, it is undesirable for other considerations that the voids be entirely filled, even with asphalt cement. Practice shows that open aggregates with considerable interlocking effect will also function satisfactorily; in fact, they are preferred by many engineers. The success of this type is not a contradiction of the facts previously stated. It probably results from the fact that a greater proportion of the load in this type is directly transmitted to the subgrade through compression, on account of the greater stability and hence wider angle of stress distribution with these aggregates. Also the type of construction inherently necessitates what are classed as fairly thick bituminous mats.

While neither design formulas nor material tests for this type of surfacing have previously been developed, they are obviously determinable; and the type is as susceptible of design control as the flexible type, and more so than the rigid slab, due to the elimination of subgrade support uncertainty. Based on the assumption that a portion of the load is supported by the direct soil reaction and the balance by beam action (of the ductile yielding type), extending the supporting area over an additional section of subgrade, it is possible to derive mathematically a logical design formula involving the variables d, depth of surfacing; W, the wheel load; S, the subgrade bearing power; f, the modulus of rupture; and e, the radius of circle over which wheel load is uniformly applied, which is

$$d = 0.564\sqrt{\frac{W}{S + 1.15\sqrt{Sf}}} - \frac{e}{2}$$

The requirements in the aggregate are similar to those for the flexible type of surface and are similarly susceptible to determination and control. The only remaining variable is that of the modulus of rupture (tensile strength) of the cementing material, which can be determined by the ductility test.

(On the basis of a mathematical analysis of the ductility test for asphalts a relationship can be developed for the determination of the tensile strength f_e involving the viscosity V, the rate of pull R, the mold size L and the ductility D where

$$D = K\frac{L^2 f_e}{VR}$$

Or, using the present A.S.T.M. penetration and ductility tests, we get the approximate expression

$$D = K_1 f_e P^2$$

where P is the penetration (using 100 gr. for 5 sec.) at the temperature of the ductility test. A paper discussing these concepts is being published by the author.)

The tensile strength can also be checked through direct tensile measurement with standardized aggregate, provided the test can be worked out so as to simulate field conditions and show duplicable results. The usual tensile-strength test, such as is applied to elastic materials, is not suitable to the determination of tension in highly plastic materials, as in the latter case immediate application of load to develop yield point is required. In the range of vehicle speeds from 5 to 60 miles per hour, the rate of load application may range roughly from 1 to 1 20 of a second—an extremely short period. The development of this type of testing equipment should present no great difficulty.

The merits of the semi-flexible type are obvious. The subgrade bearing is used to the maximum extent, both to give direct compressive resistance and to give beam resistance over the shortest possible span. The type is adaptable to increased thickness or modification in use; in other words, stage construction is possible as with the flexible type. The advantage of the rigid slab—namely, development of beam stresses—without the disadvantages that come from permanent rigidity is obtained. The design is potentially accurate and susceptible to control. The disadvantages are that a definite structural unit is not obtained, with water or other deteriorating action as a possibility. Also the materials, particularly the cementing medium, must be satisfactory and meet the requirements placed upon them. In general, the merits of this type may be summed up by the statement that with the proper design and materials, it offers practically all of the advantages of the rigid and flexible types, with very few inherent disadvantages as a consequence thereof.

Specific design problem

The principles outlined in the preceding discussion can best be illustrated by application to a specific design problem. This brief comparison is not intended to set up relative requirements between surfacing types other than possibilities of design.

The road assumed is a state trunkline highway in the prairie country, with about 800 pneumatic-tired vehicles per day, the maximum wheel load being 9,000 lb. with 1,800 repetitions a year. The soil bearing power is about 25 lb. per sq.in. under the worst of moisture conditions. Employing the accepted rec-

ommendation for Eq. (1) in the design of the rigid slab ("Concrete Road Design," Port. Cem. Assoc. *Bulletin*):

$$d = \sqrt{\frac{1.92 \times 9{,}000}{398}} = 6.59 \text{ in.}$$

This would correspond to about a 9-6-9-in. thickened-edge section with an effective depth of 7 in.

Using equation (2) for the design of the flexible surfacing, we get a depth of

$$d = 0.564\sqrt{\frac{9000}{25}} - 4.9 = 5.8 \text{ in.}$$

Applying the derived design formula equation (3) for the semi-flexible surface, using cutback asphalt as the binder, we get

$$d = 0.564\sqrt{\frac{9000}{25 + 1.15\sqrt{25 \times 227}}} - \frac{4.90}{2} = 2.63 \text{ in.}$$

The values of the variables with respect to the aggregate were those used for the flexible surface. The remaining variable f was taken at 227 lb. per sq.in. This is thought conservative considering that although there are very reasonable grounds for the belief that asphalt aggregate f values are equal to portland cement concrete values of $f = 700$, a value of $f = 400$ was taken. Further, although asphalts are self-healing and hence would not require fatigue considerations, the same factor of safety as for the rigid slab was adopted—namely, 1.76, giving the final applied value of $f = 227$.

Comparing the results for the effective depth of the three types of surfacing, we have values of 6.59 in. for the rigid slab, 5.80 in. for the flexible mat and 2.63 in. for the semi-flexible mat, if the assumptions are correct. The possibilities of the semi-flexible type of surfacing seem rather remarkable from these figures, though readily understandable when it is realized that it has the benefits of the subsoil support given the flexible type plus those of the rigid slab of extending the area of support.

Some comparison with actual practice may be of interest at this point. The stretch of road which we have had in mind in the above case and have attempted to describe by the assumptions made, was actually paved with a slab 20 ft. wide, with a 9-7-9-in. section, at a cost for grade correction and surfacing of slightly over $34,000 per mile, of which cost approximately $9,000 was for grade correction and $25,000 was for the surfacing proper. Had a bituminous mat been placed on this corrected grade, the cost would have been the $9,000 plus $4,000 or $5,000, or something under $14,000. This bituminous mat would have been 24 ft. wide or greater, and would have been approximately 1 in. thick over an inch or two of sand-gravel base. This would seem to verify the implication previously mentioned, that the formulas from the authorities quoted in this article tend to underdesign the rigid slab and overdesign the flexible (and semi-flexible) type, as judged by actual practice expressing the experience of state highway engineers.

Some economic implications may be of similar interest. The 820 vehicles per day that this road carries will bring in a revenue per mile from gasoline and license taxes of approximately $1,100 per year or $22,000 in twenty years at this rate (which assumes 12 miles per gallon of gasoline average, or $1.34 per vehicle per year income). The rigid slab represents, for surfacing alone, an original cost of $25,000, less a salvage allowance of $5,000 at the end of the twenty-year life designed for, if used as a base for a bituminous resurfacing treatment, or a net depreciation cost of $20,000; plus $22,500 total interest charges at 4½ per cent on $25,000 for 20 years and plus an average upkeep expense for right-of-way, ditches, shoulders, surfacing, etc. (not merely the surfacing alone, as this is only a part of the expense required to maintain any highway) of $300 per year or $6,000. This represents a total charge of $48,500 as against the income earned of $22,000, meaning a net loss of $26,500. The bituminous mat put in according to the state's standards would have involved a maximum investment of $5,000. Its upkeep would have improved the road, so that the salvage value at the end of twenty years should be greater than the original cost; but to allow for the possibility of location obsolescence, a salvage allowance of only $1,000 will be made, giving a net depreciation cost of $4,000; plus $4,500 total interest charges at 4½ per cent on $5,000 for 20 years; and plus an average upkeep expense for the same items as above of $8,000—an upkeep charge of $300 per year plus four "armor" coats or "drag" treatments of $500 each, which would add ½ to 1 in. to the thickness of the original mat. This represents a total charge of $16,500 as against the income earned of $22,000, meaning a net profit of $5,500. If the design were changed from the state standards to the figures given in this article, the discrepancy between the large loss on the rigid-slab type and the profit on the semi-flexible surfacing might decrease, but only a very small amount, which might easily be wiped out by resulting adjustments in the upkeep charges.

Very evidently the possibilities of the semi-flexible type of surfacing are not yet widely appreciated. It is true that the construction of what is essentially this type has become increasingly popular, yet the reasons for this have been primarily empirical; the choice has been mainly for economic reasons, with a set design followed, because it has proved satisfactory in the great majority of service. The possibilities of logical design and improvements in construction, particularly material control, from rational design and specification are not yet being used. As a result, there is no differentiation being made between the semi-flexible and flexible types, and occasional failures are resulting from lack of understanding of the type requirements.

It is believed that the rational design basis indicated by the previous discussion is obtainable without difficulty. The excellent work that has been done on soils makes the getting of reasonable subgrade bearing resistances quite practicable. On material it is quite practicable to revise or add to present methods of specifying, to provide the plastic support or beam action necessary in this type, and to assure its definite control. On the basis of present information this can be done approximately; and with the development of more detailed data on the tensile strength of the bituminous binders, and of bituminous aggregates under conditions of plastic resistance, material control equal to the accuracy of the design assumptions is possible. With the fundamental principles formulated, research should shortly supply any desired information and corrections.

Summary

Summarizing, this article has attempted to cover the following five points:

1. A comparison of the three fundamental types of usual highway surfacings has been made. A brief outline of the stresses involved and the resulting demands on the materials has been given, and a comparison of the structural advantages and disadvantages of the three types made.

2. It has been pointed out that the semi-flexible type offers great advantages for the majority of highway demands, and it is questionable whether the highway industry yet appreciates the possibility of this type.

3. It has been shown that in addition to an understanding of the design requirements, this type primarily demands a high-tensile-strength binder or cement. It is shown that methods of controlling this characteristic are possible, and attention is called to developments in the determination of the relative tensile strength of bituminous binders.

4. It is pointed out that this same high tensile strength, while not involved in the fundamental action of the type, is highly desirable in the flexible type of surfacing.

5. Attention is called to the research and detailed analysis desirable to assure the complete benefits that are possible from the use of the semi-flexible type of surfacing.

It is believed that the potential advantages of this type, both structurally and economically, are so great that highway engineers should give this subject the closest possible attention. Equations, test data, etc., are readily obtainable for the type and its modifications.

We already have a tremendous use of dynamically rigid mats, but this can be further increased and the economies already observed with this type further extended by the application of rational methods of design and material control.

AN ENGINEER'S RECOLLECTIONS

By JOHN F. STEVENS

Consulting Engineer, Baltimore, Md.

·III·

Work on the C.P.R. West through the Gold Range

False economy makes pack animals of engineers—Isolated in the Columbia Valley for the winter—The line completed in the fall of 1885—Exploring the Columbia

LATE in the winter of 1883-84 I engaged to go again with my former chief, Major Rogers, this time to the West Coast to take charge of location of the Canadian Pacific Ry. main line across the Columbia River and through the Gold Range, the river flowing on its southerly course between the Selkirk and Gold ranges. It was necessary to enter this section of the country by way of Victoria, B. C. I therefore left home early in March and went to San Francisco.

Our party numbered some 25 men, including two other engineers who were also to have charge of locating parties, and several instrumentmen, rodmen, and chainmen. We got into a snow blockade on the railroad before getting out of Minnesota, and into another one on the Union Pacific getting across the Sierras in Nevada, and were ten or twelve days in reaching San Francisco. We lost connection with our ship there, but for me at least, it had its compensation for it enabled me to hear Adelina Patti once more while she was in her prime.

We took ship at San Francisco, and after a very rough three-day voyage reached Victoria. From Victoria we went across the Sound to New Westminster and from there on a steamboat up the Fraser River to the head of navigation at Yale. At Victoria and New Westminster we picked up enough men to make three full locating parties, and from Yale we pushed ahead on foot with teams to transport our luggage to Kamloops, then a small town at the junction of the North and South Forks of the Thompson River and the lower end of

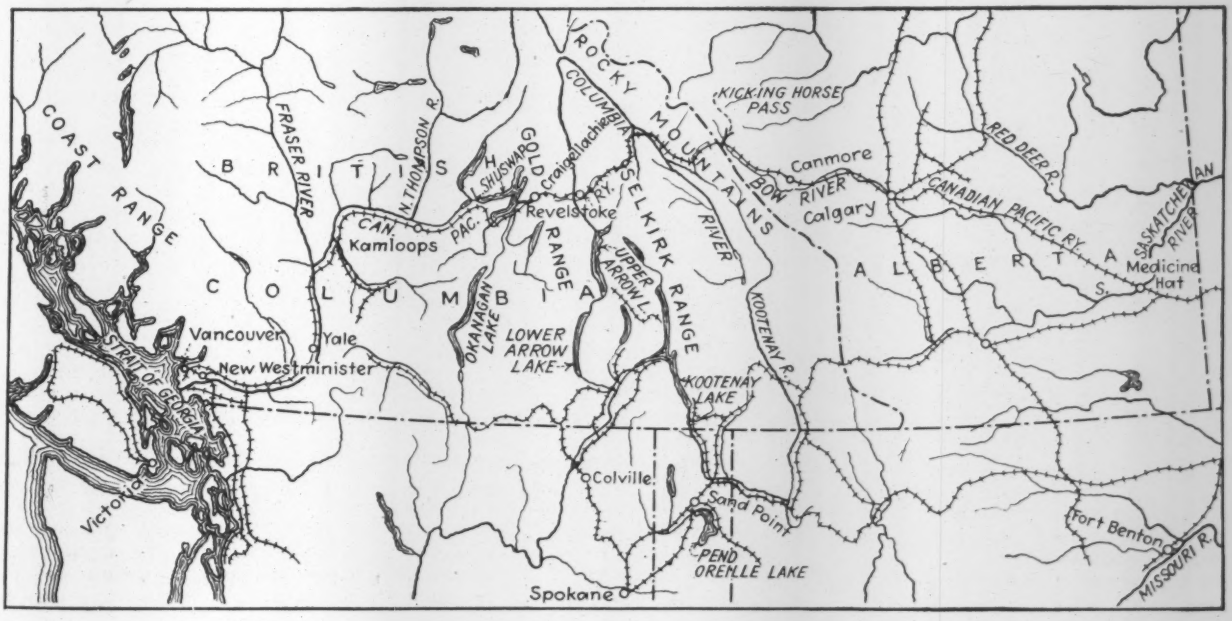
FROM the Pacific Coast the Canadian Pacific Railway, in the spring of 1884, was under construction eastward from Yale, the head of navigation on the Fraser River, toward Kamloops. By November of the following year this line joined the line from the east at Craigellachie, B. C.

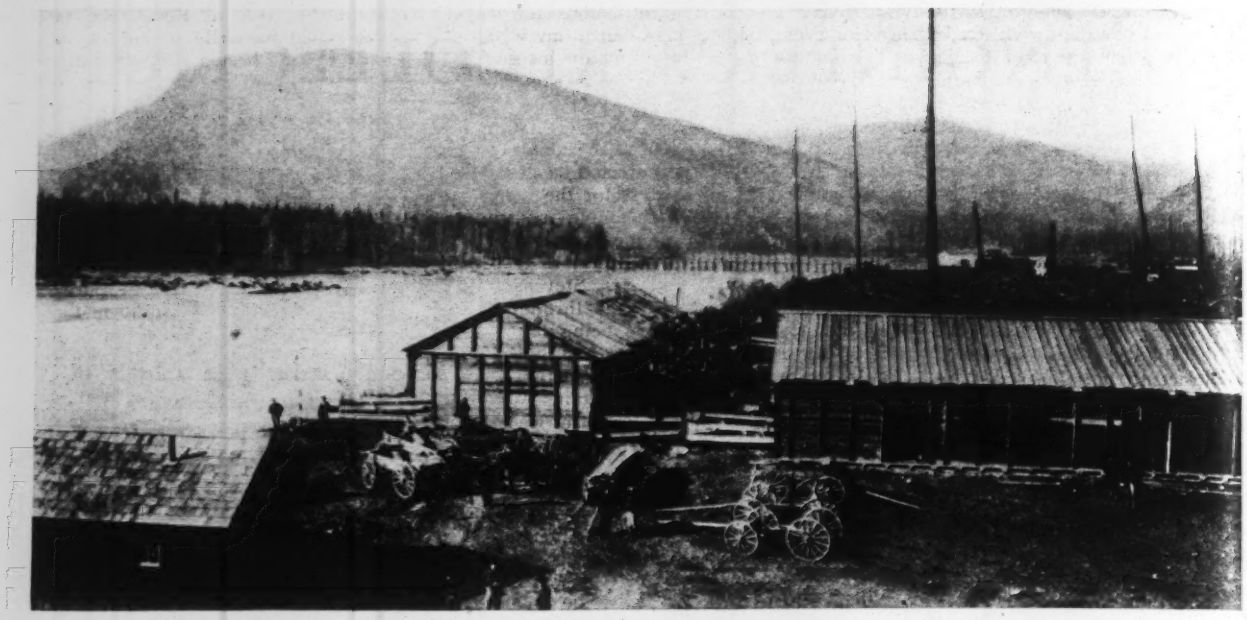
river navigation of the latter stream.

The railway was then under construction from Yale eastward, but was not yet completed to Kamloops. At the latter point we met Major Rogers, who had established his headquarters there, and by his orders Mr. Roberts' party remained there, and the other two, Mr. Watson's and mine, took steamboat passage up the South Thompson River and through the Shuswap Lakes, which lie directly west of the foot of the Gold Range. Dropping Mr. Watson's party en route, I took my party to the head of the lake and we disembarked there, with the wilderness ahead of us, and not a vestige of even a trail through it.

Over the Gold Range

I had been promised a train of pack horses and packers by the chief, and so we set at work to cut and build a trail as quickly as we could to have it ready as far as possible before the arrival of our





DURING THE WINTER of 1884-85 cribs for the bridge over the Columbia River in the distance were built on the ice. The log camp used for winter quarters was near the far end of the bridge under the mountain. This and the accompanying view are made from rare photographs loaned by the Canadian Pacific Railway.

horses. But after we had some few miles of trail finished, no horses appeared; so, to avoid loss of time, we packed on our backs our tents, cooking outfit, baggage and the month's food supply for twenty men and began immediately to extend the trail farther into the mountains.

This experience was repeated until we had cut and built the trail clear across the range to the Columbia River, for we were not provided with pack horses until the middle of the summer, through some negligence or design at headquarters at Kamloops—I never knew which.

I had expected to build the trail, but that engineers and their helpers (for we all packed alike, myself included) should be obliged to make pack horses of ourselves when proper transportation could have easily been provided was poor economy, to say the least. However, we made the best we could of it, for the line had to be located that season without fail. I can see myself yet, with a tump line across my forehead toiling up a muddy trail carrying a pack made up of a grindstone and a sack of flour, and trying at the same time to absorb what I could of the topography of the country.

Camped at the summit

We found four small lakes en route, three of which were hemmed in by bluffs, so that a trail such as we could build around them was impracticable; we therefore crossed them on rafts which we built, using long sweeps to propell them. It was a hard trip, some of it through deep snow, over immense logs and through swamps which we had to corduroy before we could walk across them. But we finally made our camp on the summit, which was only 7 miles from the Columbia River, and there we began our real work of surveying.

The steamboat which plied upon Shuswap Lake periodically brought our food supplies to the Landing, from which we had to pack them on our backs to our camp wherever it happened to be, until the late arrival of our horses. But we pushed our work of surveying as fast as was possible through the thick forests and along the mountain sides, and made good progress notwithstanding the difficulties. The weather was wretched that summer, scarcely a day passed without a cold rain or sleet, and we were never dry for two months except when in our blankets, and not always then.

Trouble over the food

Our food menu was flour, bacon and beans for the staples—wholly inexcusable, for there was a great variety of food at Kamloops. Finally after repeated complaints, all my men except instrument, rodmen and cook struck, on account of the small variety of food, and I gave them time checks and sent them back to Kamloops. I immediately sent out for other men and in a week or two had a full crew once more.

I had picked up a young raw Highland Scotch boy at New Westminster, and when the men struck he came in rather bashfully for his time too. I had been watching him all along, and I felt that there was the making of a man in him, so when he appeared for his time I barked savagely at him and refused to let him go, but told him to get out of my tent and attend to his business. I scared him all right, as he has often told me since.

A general in the making

This young fellow stayed with me on the Canadian Pacific and afterwards on other roads for several years, learning the rudiments of railway engineering fairly well, and finally getting to be a railroad contractor and a very successful one. He has handled very large contracts, millions of dollars worth for the Canadian Pacific, and his firm built the Grand Trunk Pacific Railway through to the Pacific Ocean; in fact, his firm was for years the largest one in the Northwest and Canada.

At the outbreak of the Great War by invitation he went to see Lord Kitchener at London; as a result he went to France, and built all, and had charge of the narrow-gage rail lines from the permanent railhead to the British front. He came out of the war a Major General, a title which he does not use if he can help it. I would say more about him and his activities, but he is an extremely modest man, and will not like what I have already said of him, if he happens to read it. But General John W. Stewart, once and always "Jack Stewart" to me, is a very near and dear friend, one whose friendship has meant much to me in the past.

In regard to the character of our food supplies: I was told afterward that my chief, Major Rogers, complimented me to the extent of saying that I was an able engineer and did a lot of good work, but he qualified his words of commendation by saying that I "made a god of my stomach," meaning thereby, that my somewhat emphatic demands for something besides bacon and beans marked me as being an effeminate gourmet. In passing, I may say that my

cardinal principles in handling men have always been to pay them well, feed them well and to work them hard, but no harder than myself, and to ask them to take no chances that I did not take myself. The average man will do his best work when following a leader—but not, when under a coward or a shirker.

Settled for the winter

Late in the season of 1884, the government of British Columbia built a wagon road through the Gold Range, following substantially the pack trail which we had put through. About the same time the Canadian Pacific awarded the contract to build the railway line which I had located through the Gold Range from the lake to the Columbia River, and I was given charge as engineer of its construction; this meant that I would be there at least another year, and acting on her own initiative my wife decided to come out and join me.

Leaving our home in Minneapolis, with our boy then only two years of age, she went to Portland, Ore., and thence by ship to Victoria, B. C., where I met them. From there we went by steamboat to Yale on the Fraser River. During the past season the railroad had pushed its track as far as Kamloops, and we made this lap of the trip in the caboose of a construction train, taking two days for the journey. It was a rough experience for a woman, especially with a young child to care for, but she never murmured or complained. At Kamloops we took the steamboat up the Thompson River and Shuswap Lake to the "Landing," and from there we drove by team over the new rough wagon road through the range to the Columbia River. It was a hard tedious journey for even a strong man, but in my wife's case it was but one of many instances where she proved herself a wonderful helpmate and was in every way a heroine.

At Columbia River the contractor, G. B. Wright, had erected large and comfortable log quarters for the winter, and was getting in an ample supply of stores of all kinds for the winter's work. His wife was with him and their two well-grown boys, and Mrs. Stevens, our boy and I lived with them through the winter, the two women being the only white ones within a hundred miles in any direction. Our only connection with the world outside the mountains was by the route I have described. But we were congenial and had a comfortable and happy winter, as nearly perfect as any that we ever passed.

Our work during the winter consisted in clearing the right-of-way, in cutting cross-ties and timber, and as will be noted later, putting in the wooden crib piers for the bridge across the Columbia River. The contractor had some hundreds of men employed in the different kinds of construction so that when spring opened we would be ready to begin the larger task of grading and bridging the line to make ready for the track.

Bridging the Columbia

High water in the Columbia River, resulting from the late melting of the snow in the mountains, generally occurs in the early summer, along about the latter part of May and in June. The current of the river at Revelstoke (it was then called Farwell) is quite swift, and it would have been a difficult matter to hold and sink the crib piers during high water, which might last two or three months. I knew, therefore, that it was of vital necessity to get the cribs in place and sunk during the winter.

The river was low and running full of broken ice, broken up by passing the many rapids and falls of the upper river. So I conceived the idea of blocking the running ice until it froze clear across from bank to bank. I was confident that it could be done, had designed the cribs, and had men getting out hewn squared 12x12 timbers, and opened up a quarry of suitable rock a mile and a half up the river.

Under my directions the contractors made a boom long enough to reach across, allowing for camber, and got it stretched across the river. It was made of uniformly sized logs held together by iron toggles made by the blacksmith. And all that happened was that the broken ice piled up a foot or two high against the boom, and then popped under and went on downstream. It was not encouraging, and I was subjected to a lot of good-natured jeers about engineers. Then I had another similar boom made and strung it across about 50 ft. from the first one—result, nothing, excepting that the comments increased.

Almost immediately the weather turned colder; a couple of days later the ice stopped running the river was frozen clear across, and in a day or two more the ice above the booms was thick and strong enough to carry teams with heavy loads safely for some miles up stream. Below the booms the river kept open.

DRIVING the last spike on the C.P.R. line to the Pacific Coast, Nov. 7, 1885, at Mr. Stevens' camp at Craigellachie.

The laughs ceased, and it was hustle day and night to get the timber cribs, piece by piece, in place, over holes cut in the ice of the shape and a trifle larger than the cribs, filling them gradually with rock and sinking them to safe foundation on the hard gravel at the bottom of the river.

I felt very pleased at the outcome. It was merely one of the many instances in the life of an engineer which go to show that a purely technical education (I never had any) does not always fit him to grapple with and solve unusual problems that arise. "Horse sense" and the nerve to try doubtful experiments often succeed in the face of difficulties.

We had only one notable visitor that winter; the bishop of the English Church came through over the rough trail which the forces from the east had built through the rugged Selkirk Range. He was a fine energetic personage, and we enjoyed and deeply appreciated his coming to visit us in that wilderness. Other than on the occasion of his short sojourn with us we were left to entertain ourselves, which we did happily; and when spring again arrived and we broke up our home circle, it was with deep regret.

The next spring Sir William Van Horne, the president of the Canadian Pacific, went through the mountains over the line. His trip was very inspiring, to me at least. I have never forgotten, after 48 years, the vigorous and breezy comments about the country and everybody connected with it which he made when we had pulled him back onto the raft after he had fallen into the icy waters of Summit Lake.

A new camp

As soon as the snow had gone sufficiently to permit the work of grading to go ahead, I moved my engineers out upon the line, establishing them in various camps of their own convenient to the work. Selecting a good camping spot about midway of the section of the line of which I had charge, I set up a fine camp of large tents, fitted with wooden floors and other refinements, and furnished it in a comfortable manner. Here, with a very competent Chinese cook, we spent the summer of 1885. Gradually as the construction was being pushed nearer and nearer to us from the east, we began to see more and more visitors, and these with the interesting work that I had in charge kept us busy.

Completion of the line

Everything moved along smoothly, and we were fortunate in having fine weather, in marked contrast to that of the previous year. The track was being laid from both the east and west, and as our work was completed just before the track reached us, it met just at our camp; and the spikes of the last rail in the Canadian Pacific Railway, which joined the Atlantic and Pacific oceans by the new lines of steel, were driven on Nov. 7, 1885, where we had spent the summer, the station now being named Craigellachie.

The completion of the great transcontinental line that year marked the end of my service with the Canadian Pacific Railway Co., and closed four years of a strenuous but altogether satisfying and valuable experience. I had been in personal contact with many difficult situations, but I had managed to conquer them, and the solution of many perplexing problems had given me a confidence that I felt nothing in the future could ever shake. I knew that on the whole my work had given satisfaction to my outranking officers, and that while I had not gotten any large money remuneration for my efforts, I had amassed a store of knowledge which would be of incalculable value to me in the future.

Twice during the summer I was drafted by James Ross, the manager of construction for the railway company, to go down west to sections of the work on the railroad that were being handled by engineers who had gotten their experience on government railways in India. There were no problems not easily solved, and I think that such as they were they would not have arisen had a "noble experiment," but one enforceable, been in progress.

Exploring the Columbia River

When the work was completed and my services were no longer needed, we began to think about our home in faraway Minneapolis, but before going there I wanted to see something of the lower Columbia River country and especially Spokane. Mr. Ross, knowing of my desire, invited Mrs. Stevens to use his private car, which was leaving shortly for Winnipeg. She did so and had a very comfortable journey, arriving home in Minneapolis in December, both she and the small boy in good health.

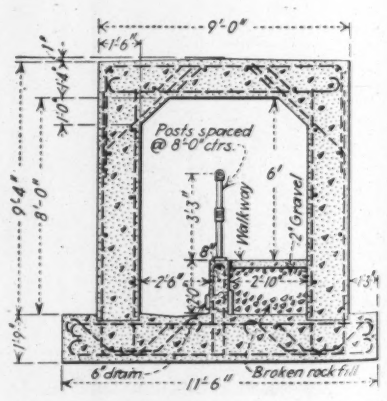
Finding three other men who had the same ambition that I had, we bought a small rowboat and set off down the Columbia River, going through the beautiful Arrow Lakes, shooting the big and dangerous rapids at the mouth of the Kootenay River, and after several days' rowing and floating crossed the boundary line into the United States at the Little Dallas, below which point navigation of the river was impracticable. Here we luckily were able to get a settler to drive us to Colville, and from there we went by stage to Spokane, 85 miles distant.

Shortly after our arrival at Spokane we learned that we had been followed all the way by a small gang of toughs, who thought that we had a lot of opium that had been stolen up on the Canadian Pacific, and that we were smuggling it into the United States. We had heard of no opium and did not hurry our journey particularly, but these men had not been able to get within a day's travel of us, which certainly was our good fortune. One of them was hanged for a bestial crime committed shortly afterward. Coming down the Arrow Lakes and the river, we would camp for supper at some attractive-looking place, cook our supper, and in due time would silently slip away to some secluded spot for our night's rest. This was a matter of general principle with me, for I had gained enough wisdom by experience not to depend too much on the benevolent intentions of casual tourists in a wild country.

After spending a few days in Spokane I went home to Minneapolis, and began again the weary old game of waiting for spring and another engineering engagement. But I looked back then, as I do still, upon the four years that I spent on the location and construction of the Canadian Pacific Railway with great satisfaction. While my salary was small, the experience that I gained could not be adequately measured in dollars.

Pedestrian Underpass and Culvert Under Railroad

A NOVEL 6x8-ft. culvert with a walkway for pedestrians has been designed by the U. S. District Engineers of the Zanesville, Ohio, office for use in connection with relocation of the Pennsylvania Railroad, to permit construction of the Dover Reservoir of the Muskingum Valley Flood Control project. The combination culvert and walkway will be used under the railroad tracks in lieu of a standard 4x4-ft. concrete box culvert originally designed for the location for drainage purposes alone. Structural details of the combination culvert are shown in the accompanying drawing. It will be 120 ft. long and will contain 318 cu.yd. of concrete and 50,000 lb. of reinforcing steel. The walkway is protected by a pipe railing.



COMBINATION drainage culvert and pedestrian walkway under railroad tracks.

New Building Demonstrates Modern Wood Construction

Structure for housing miscellaneous test projects at Forest Products Laboratory incorporates factory-made units in the form of plywood wall and roof units and of solid roof arches built up of glued laminations

By L. V. Teesdale
Senior Engineer, Forest Products Laboratory, Madison, Wis.

A BUILDING using plywood for finish on outside walls and for inside lining and roof sheathing incorporating built-up arches, some glued and some of solid timbers with dowel connectors, has just been completed on the grounds of the U. S. Forest Products Laboratory, Madison, Wis. Although intended primarily for service purposes, the building affords an objective demonstration of the adaptability of wood to modernism in both design and construction.

The building is in two sections, one a storage and testing unit 160 ft. long, 46 ft. wide, 12 ft. high at the walls and 19 ft. high at the center, and the other is a garage 64x24 ft., with a roof height of 12 to 14 ft. In design, it is in keeping with the main building and other structures on the grounds. Its construction embodies special features developed or adapted through research at the laboratory. Such features, widely discussed in the American wood and building industries of late years but as yet largely unused, are based on the idea of factory-made wood structural units suited to quick and economical erection, and at the same time adequate to the requirements of strength, serviceability and appearance.

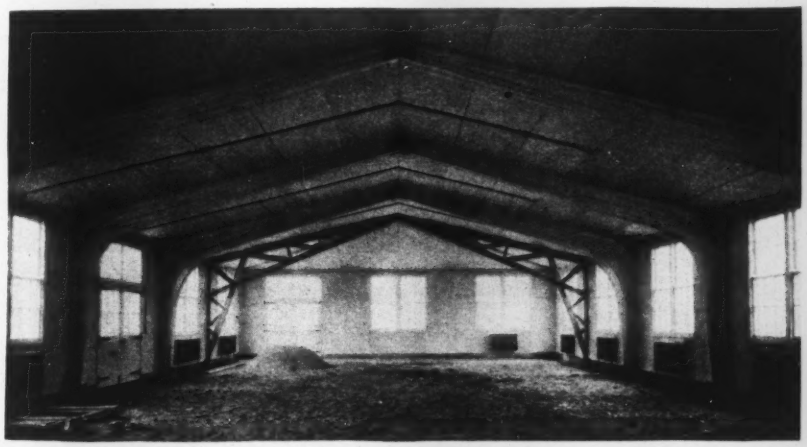


FIG. 1—SOLID ARCHES of rectangular and of double I-beam section, built up of glued laminations of 9/16-in. material, support the plywood roof of the new building. A trussed arch framed with steel joint connectors was also used, so that a three-way comparison is possible.

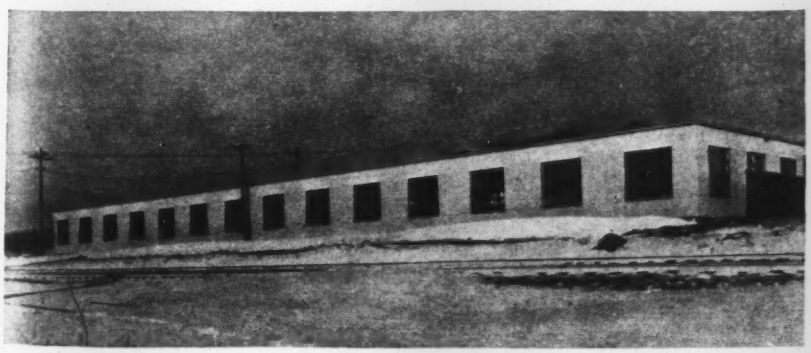


FIG. 2—EXTERIOR OF BUILDING presents a smooth surface of plywood sheets with double windows in each bay.

In designing the main section, requirements were for unobstructed floor space and ample overhead clearance for sawmill and other industrial projects, for which reason arched supports were chosen in preference to column-and-girder or standard truss construction. The results of previous studies were useful in the design of three-hinged arches glued and built up from small material, to give service equivalent to that of high-quality solid timbers.

Two types of glued arch were provided—one solid and one of double I-beam section. A third type to be included was a trussed arch held together at the joints with split-ring and hinge-and-plate connectors. Five solid arches and two each of the composite types were built and symmetrically disposed in the building, solid arches at the middle bays, double I-beam arches next, and trussed arches at the ends. The halves of the large glued arches were bent at the knee but were straight below and above the knee, taking the familiar boomerang shape, and were held together at the apex with bolted plates. Flanged plate bearings for all arches were provided at the foundations, which were built to withstand a side thrust of 10,000 lb. at each footing. A maximum roof load of 4 lb. per sq.ft. was assumed, including dead load, wind and snow. The arches were designed to carry live loads either uniformly distributed or acting on half the roof only.

The solid arches were glued up of laminations of $\frac{9}{16}$-in. material to a width of $11\frac{1}{2}$ in. and a thickness of 12 in. at the base, 24 in. at the knee, and 8 in. at the apex. Each layer was made of 4-in. and 8-in. pieces, with the edge joints staggered in alternate laminations. The length of individual pieces varied from 6 to 16 ft. To obtain the length required, such pieces were glued together at the ends with a scarf joint having an angle of 1 to 12.

The chords of the double I-beam arch were built up of similar laminations. The bottom and top chords, 6 in. thick and 8 in. wide, were cut lengthwise into three pieces with a band saw, the center section being $3\frac{1}{2}$ in. wide and the two outer sections $2\frac{1}{4}$ in. wide. The center sections of the two chords were then boxed together by gluing on Douglas fir plywood plates 1 in. thick and of the desired outline, after which the outer chord sections were glued on to form flanges. The completed arch was 21 in. thick at the base, 36 in. at the knee, and 12 in. at the apex. Casein glue was used in the arches as well as in other glue work throughout the building, except in the premanufacture of sheet plywood.

The trussed arches were constructed of chord members 6x8 in. in section and of web members in sizes ranging from 2x4 to 4x6 in. Joints at the knee were

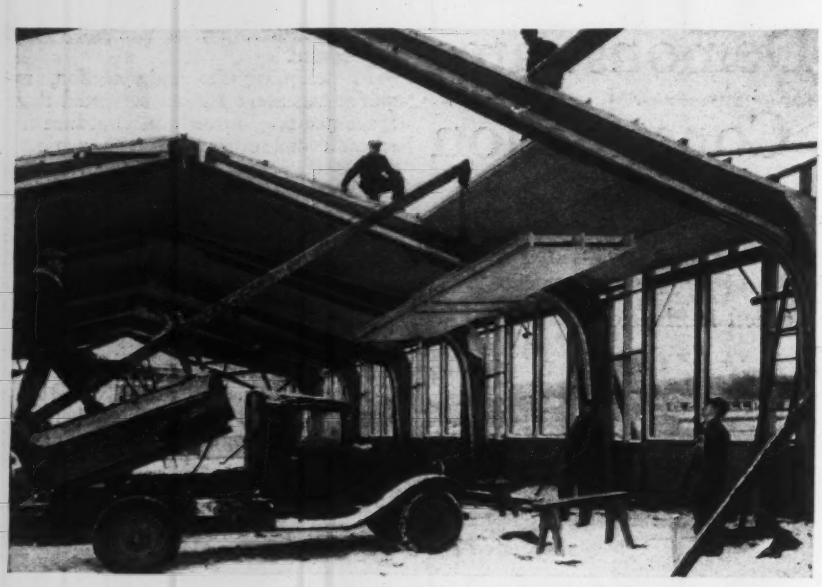


FIG. 3—INSTALLING ROOF PANELS made up of joists with stressed plywood covering top and bottom. All structural elements of the building came to the job in prefabricated units.

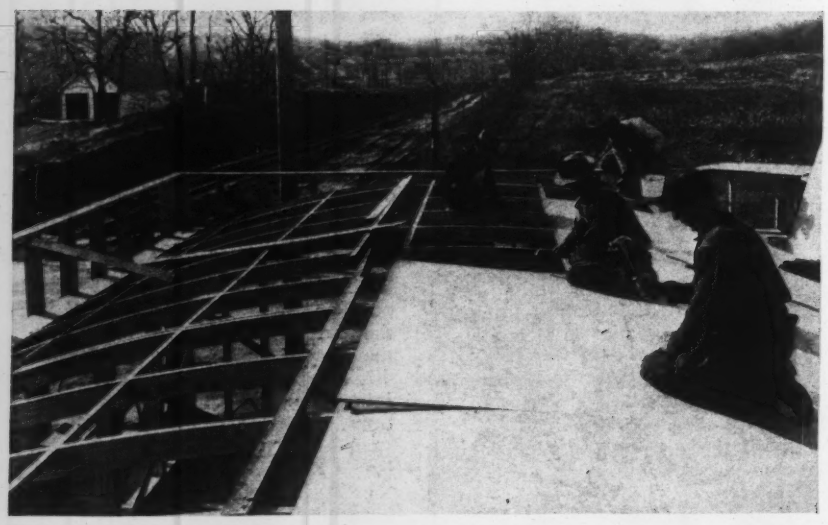


FIG. 4—GLUING AND NAILING plywood sheets on low-rise arches of garage roof.

formed with steel connector assemblies, in which stresses are transmitted from the wood member by inset claw plates to straps or flat plates, which are socketed at the joint proper in a double-ringed inset and through-bolted "hinge connector." Other joints were made with split-ring connectors, which are recessed in precut grooves on opposing faces of members to be joined, the latter then being drawn together with a bolt. Offsetting the cost of the so-called modern connectors is the fact that, by efficiently distributing stress over a large area of wood, they obviate the oversizing of members merely to provide seating for the large number of bolts that would otherwise be needed to obtain a safe joint.

The roof deck of the main section of the building consists of built-up panels. Each unit, forming a large flat box beam with stressed coverings, consists of an upper and lower sheet of Douglas fir plywood 4 ft. wide and 16 ft. long, glued to three 2x6-in. joists, one at each edge and one in the middle. The upper sheet, 5 ply and $\frac{5}{8}$ in. thick, forms the roof sheathing, while the lower sheet, 3 ply and $\frac{3}{8}$ in. thick, provides a smooth ceiling. Previous tests had demonstrated that such units, owing to the stress value of the plywood itself, have strength and stiffness equivalent to that of ordinary decking supported by 10-in. joists. These box beams or roof panels were joined together at the edges by splines in the outer joists, and were fastened at the ends to the arches by nailing through the lower sheet. To facilitate nailing, the upper sheet was left 6 in. short, and the space was filled in after erection. Included in the construction of the panels was an insulating blanket fastened at mid-height of the joists. The roof covering is tar and gravel.

Walls were framed with 2x6-in. studding spaced 24 in. on centers, and were covered on the outside with 5-ply $\frac{5}{8}$-in. yellow poplar plywood glued on the hot press with water-resisting artificial resin glue and installed in sheets 4 ft. wide and 4 to 8 ft. long. The wall extends upward to form a 2-ft. parapet. The studs were cross-braced at each horizontal joint of the plywood, and midway between joints where the height of sheets was 8 ft. Both horizontal and vertical edges of the sheets were bluntly V-jointed and were spread with an elastic composition, shoved into place, and the sheets nailed to the studding. A sheet-metal drip was provided at the bottom of the wall. All exterior walls were given two coats of aluminum priming paint and two coats of lead-and-oil finishing paint.

Inside walls were of 3-ply $\frac{3}{8}$-in. Douglas fir plywood. This, as well as the Douglas fir plywood used in the roof panels, was built up with a commercial moisture-resistant glue of specified quality.

Wall construction in the 64x24-ft. garage section was similar in all respects to that of the main section. The garage roof, however, having about half the span of the other, is supported on lighter arches of bowstring type. These were built up to a depth of 5 in. with glued laminations $\frac{5}{16}$ in. thick and $1\frac{1}{2}$ in. wide. They were spaced 30 in. apart. Instead of a tierod at each arch, "skew-

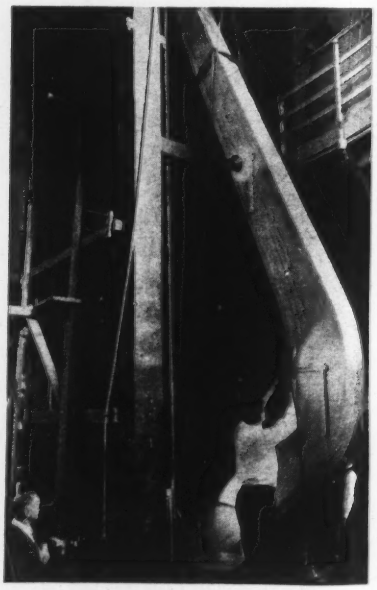


FIG. 5—TESTING a half of a solid laminated roof arch as a bent column. Several duplicate arch members are undergoing these and similar tests.

backs" were provided at the wall line to take the thrust. These were glued up of six 2x12-in. planks each. They were recessed slightly, to receive the arch ends, and tied together by 1-in. rods, 8⅔ ft. apart. Roof sheathing over the garage consists of 5-ply ⅝-in. Douglas fir plywood in sheets 4x10 ft. glued and nailed to the arches.

Windows, in which wood sash was used throughout, occupy half the perimeter of the building. The garage is floored with 6-in. concrete. The main section is unfloored except for compacted gravel. Adequate heating and lighting and other necessary services are provided.

The building, as completed, stands as a study of the problem of wood construction in its more progressive aspects, though not necessarily as its final solution. Tests on full-scale duplicates of the large arches are now in progress (Fig. 5) and are giving a quite satisfactory check of design factors. The cost of the building complete, just over $23,000, or 15½c. per cubic foot, even though it includes extra pioneering expense in arch fabrication, compares favorably with the cost of ordinary construction, and lower costs on similar projects under standard production conditions may naturally be expected. The type of construction made it possible to enclose the building very quickly. The nine large arches were erected by six men using a hoist in 1¼ days, and the roof panels in two days; the outside plywood panels were placed by four men in less than three days.

The contractor for the arches was Unit Structures, Inc., Peshtigo, Wis., whose operation began with this project. Hot-press plywood for exposed outside walls was supplied by the Haskelite Corp., Grand Rapids, Mich., and cold-glue plywood by the Harbor Plywood Corp., Hoquiam, Wash.

Why Can't Uncle Sam Prime the Pump?

By Farley Gannett
Consulting Engineer, Harrisburg, Pa.

THE two instances which Mr. Gannett cites in the following article are true stories. They graphically illustrate the present tendency among municipal officials, as well as corporate officials, to leave it up to Uncle Sam. The same disintegrating effect on the laboring man that is resulting from continuation of the dole is apparently also developing in officialdom by reason of Uncle Sam's continued largesse.

—EDITOR.

THE MAYOR was speaking: "Gentlemen, what we want is a 100 per cent gift. We had to put up too much city money on that last CWA job, and this time we are going to get it *all* from the government. Others have gotten it; why shouldn't we?" His views were echoed by the finance commissioner, who added that the city had been operating for two years on a pay-as-you-go basis and would keep on doing it as long as he had anything to say about it. The congressman jumped to his feet and vociferously added his commendation of the mayor's remarks, closing his speech with: "Nothing but 100 per cent for us, I say." The group of influential citizens sitting around the room nodded their heads in assent.

The subject under discussion was ways and means of completing a construction job of considerable magnitude and great importance to the city, which had been started when the CWA was first conceived. The sum of $300,000 had been presented to the city by the CWA and was spent for wages during the winter and spring and distributed to the stores, landlords, banks, city treasury, etc. To match this sum, the city contributed $6,000 for machinery rental and materials. Now $350,000 more was wanted, but the city wasn't going to strain its resources to contribute any more. Uncle Sam had to cough up all of it. Why not?

"We don't want any of this damn PWA 30-70 per cent money. We want 100 per cent, that's what we want. Others get it that way, why shouldn't we; we may be in a Republican state, but don't forget we have a Democratic congressman, and he ought to know how to get it for us." This time it was the chairman of the citizens' committee who was speaking.

Two days previously the finance commissioner had made clear the financial situation of this city of 75,000 people. It appeared from his records that the city would end the fiscal year with a balance of $150,000 in the bank, but half of it would be needed to carry on until the next tax payments began to flow in, and the rest had to be held for some unforeseen emergency that might arise. So, of course, the city couldn't spare a cent for this job. It was admitted that the bonding power of the city was still ample, but this was a pay-as-you-go administration.

When the catastrophe occurred which made this job necessary the year previous, the city promptly employed engineers to make a thorough study and report. There wasn't a moment's hesitation about the expenditure for this work, nor was there any doubt about the intention to spend whatever was necessary of the city's funds or credit to do what was necessary to prevent a recurrence. But that was before the CWA had been conceived and while the PWA was yet a child in swaddling clothes.

Now things are different, and free money is to be had. The farmer who loses his crops gets paid for them anyway; he doesn't have to watch the weather signs any more and plan and scheme to get a good crop. The hog raiser gets $5 for hogs he doesn't raise, so "Why shouldn't our great city get all the money it will cost to prevent another catastrophe like that of last year? We didn't cause it. God brought it on us, just as He brought on the drought and the Mississippi floods." "Between you and me," says the man behind the city government, "we could build this job and get the money back in a few years through increased property assessments, due to increased land values, just as the city of E—— did some years ago; but why should we cough up all that money when Washington can be made to think it is saving the nation by giving it to us?"

Another city—another state—another day

About the small room are seated eight men, each representing an industry or a community of national reputation. The chairman of the meeting, a dignified, white-haired official of a corporation whose products are used by millions, is talking: "Gentlemen, we have been to Washington and have interviewed the PWA. Our matter has been given special consideration; we presented it to the advisory committee, were well received, and our method of presentation was highly complimented by the board chairman. It looks very much as though we will get the $2,000,000 that we need to build our project, and thus greatly improve conditions in our cities and for our industries. You all realize, as I do, that we must ask for the full 100 per cent of the cost because other projects, not so worthly as ours and far larger, are being thus financed as special projects by the PWA where large areas are benefited and where interstate questions are involved, as in our case." His remarks are greeted with nods of approval by the other gentlemen present, and he is much commended for the success resulting from his untiring efforts to get their share from the national treasury.

The chairman then rises and in a somewhat changed voice tells his committeemen that it is necessary to have $1,000 at once to carry on the work in Washington, to pay expenses necessarily arising in a matter of this sort. There are engineers' and lawyers' fees

and traveling expenses of these men and himself to and from Washington, etc. He asks each company and community represented at the meeting to guarantee $100. Like pulling teeth, he finally collects promises for $500.

Any one of the interests there represented could, even in these days, have raised the money for this project, some from cash on deposit, others by credit—but why should they? "Let George do it."

The handing out of all these funds from the national treasury to municipalities is very soon going to have the same effect on local public officials that the English dole and the United States FERA is having on the unemployed who are being supported by these funds.

The reason that the pump isn't being primed by all these artificially inspired public enterprises is because the attempt thus to prime the pump of enterprise is developing an attitude of "Let George do it" (Uncle Sam) rather than developing in municipal officials and private officials the desire to take off their coats and go to work with their own initiative and their own funds. A pump can't do its work if the suction line is decayed.

A Method of Calculating Efficiency of Filtration

Defined as the ratio of the actual plant output to the nominal capacity, filtration efficiency may be calculated from experimental findings of the relationship between filtration rate and length of filter run

By Herbert E. Hudson, Jr.

Junior Sanitary Engineer, Experimental Filtration Plant, Chicago, Ill.

THE BEST WAY of defining efficiency of filtration, in the opinion of the author, is "the ratio of the actual output of the filtration plant to its nominal capacity" (filter area multiplied by the filtration rate in use). Based on the relationship between the rate of filtration and the length of filter run as found at the Chicago experimental filtration plant, a method of calculating efficiency so defined has been developed. It is a method that can be applied at any filtration plant, but it has to be worked out for the particular conditions which occur at that plant. An example of calculation of filter efficiency for a large plant will be given, but this particular illustration holds only for the conditions that were used in this study.

The efficiency of a filter will depend upon the lengths of the filter runs, the rate of filtration, the amount of washwater used and upon the time the filter is out of service for washing. In calculating the efficiency, it is necessary to know or to assume the conditions that will obtain. In the following illustration estimates have been used based on experience at the Chicago experimental filtration plant. Tests there have shown that:

(*a*) Satisfactory cleaning of the filter beds can be accomplished with a washwater rate of 15 gal. per sq. ft. per min.

(*b*) The time out of service per wash will be about 45 min. At some plants this would be too long a time, but when it is considered that this includes filtering down the water in the filter at a reduced rate, it is not too long for a large plant.

(*c*) The duration of the wash should average:

$$W = 1.08 \sqrt[3]{R} + 0.5$$

where W equals minutes wash per run, and R equals length of run in hours. This includes 0.5 min. for slow opening and closing of the wash valve. It is assumed that no wash of less than 2.5 min. will be used. There will be considerable variations from this, but it is believed that this formula represents fairly well the average time of wash that is needed at Chicago for any length of filter run on the sands used. Longer washing does not cut down the washwater turbidity very much.

(*d*) It is estimated that in a large plant about 3.2 per cent of the filter area may be ineffective. This represents 1 filter out of service for repairs in a plant having 35 filters, an allowance for chemical feed water, etc.

(*e*) The lengths of filter runs will vary according to the relation:

$$H = \frac{K}{V^{1.5}},$$

where H is the hours filter run, to 8 ft. loss of head, V the rate of filtration in gallons per square foot per minute, and K a constant dependent on the treatment applied.

There is considerable experimental evidence that this relationship (*e*) between length of filter and filtration rate is valid. Some of the evidence will be presented later in the article.

An illustrative example provides the best way of explaining the calculation of efficiency. Let the first condition be that under the circumstances of preliminary treatment, filtration rate and filter characteristics, the filter run is 10 hours. Add to this 0.75 hour out of service for washing, giving 10.75 hours. With this gross length of run, we will have 2.23 runs per day, and the actual time of filtration per day will be 22.3 hours. The quantity of washwater per wash will be 15 g.p.m. per sq.ft. multiplied by 2.83 min., or 42.4 gal. per sq.ft. Multiply 42.4 gal. per wash by 2.23 runs per day, and we learn that 95 gal. of washwater are needed to keep each square foot of filter area clean each day. Each square foot of filter area will actually be filtered for only 22.3 hours, producing, at a 2-g.p.m. per sq.ft. rate, 2,676 gal. of water each day. From this we must subtract the washwater used.

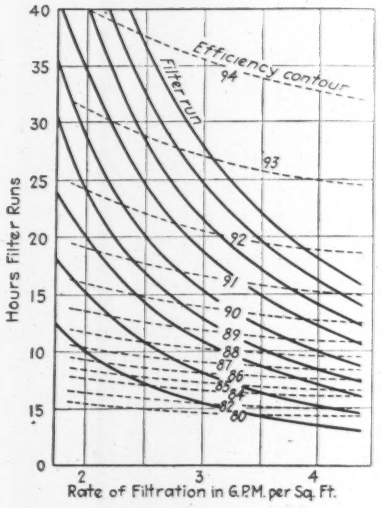


FIG. 1—EFFECT of rate of filtration on filter run and filter efficiency.

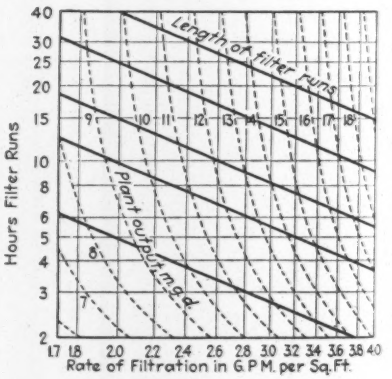


FIG. 2—EFFECT of rate of filtration and length of filter run on output of 10-m.g.d. filter plant.

and will have left 2,581 gal. available for consumption.

$$\frac{\text{2,581 gal. filtered per day}}{\text{2 g.p.m. per sq.ft.} \times \text{60 min.} \times \text{24 hr.}} = 89.6 \text{ per cent efficiency.}$$

It has been assumed that only 96.8 per cent of the filters would be available, so that the plant filtration efficiency is 96.8 x 89.6 per cent, or 86.9 per cent.

The relation between the rate of filtration and the length of the filter run as it has been stated in the foregoing equation (e), for various conditions of preliminary treatment and filter characteristics, has been plotted in Fig. 1 as a series of solid lines. The length-of-run curves are shown for various treatments. Knowing the length of run a treatment will produce at any given filter rate, one can parallel these curves to learn what length run will be produced at another filtration rate. The broken lines pass through points of equal efficiency as determined from the filtration rate and filter run.

A filtration plant having 31,200 sq.ft. of filter area operating at 2.0 g.p.m. per sq.ft. is called a 90-m.g.d. plant. However, if its filter runs are 10 hours long, it produces only 78 m.g.d. If the operator doubles the filtration rate, according to Fig. 1, he will cut his filter runs to 3.4 hours, his efficiency to 75 per cent, and instead of producing 180 m.g.d. the plant gives only 135 m.g.d. In an extreme case a plant might even produce less water when its filter rate is increased.

Naturally, the assumptions and facts used in this study are not applicable everywhere. However, the method can be applied to any filter plant by substituting the relations that hold true there. For example, Fig. 2 has been constructed for a 10-m.g.d. plant in which it has been assumed that the filters would be out of service for 25 min. per wash, and that about 45 gal. per sq.ft. per wash would be used irrespective of filter runs. It was further assumed that the same filter run-filter rate relationship held, and that no filters were out of service for repairs. The dotted lines in this example represent plant-output contours. To use this graph for finding what rate of filtration is necessary to provide any desired plant output, parallel the solid curves from the known filter run and rate to the desired plant output. The abscissa of this point is the desired rate of filtration.

To substantiate the assertion that the relation between rate of filtration and length of filter run can be expressed by

$$H = \frac{K}{V^{1.5}},$$

some of the experimental evidence will now be presented.

At the Chicago experimental filtration plant there are two automatically controlled rectangular concrete filters of 100 sq.ft. of filtering area each, ten hand-controlled circular steel gravity filters of 10 sq.ft. area each, and 22 small automatically controlled glass-tube filters of about 0.017 sq.ft. each. Careful observations on the performance of the various groups of filters have shown that they give nearly identical results.

The concrete filters were not used in the experiments on the effect of rate of filtration, except to check the lengths of runs on the smaller filters that were operating at the same rate.

The smaller steel filters were equipped with venturi meters, and flow through the meter was controlled manually by a valve, set each hour by the filter operators in such a way that the average rate each hour was the desired rate. A totalizing meter was also installed on each of the steel-tank filters, and effort was made to maintain the same quantity filtered each hour. Admittedly this did not give an exactly constant rate of filtration, but comparison of the results with those from the 100-sq.ft. filters showed that the variation was negligible.

Six of the glass-tube filters were set at various filtration rates. They were washed at a rate which expanded the sand 50 per cent until the washwater appeared to have a turbidity of about 5 p.p.m. These filters as well as the steel-tank filters were equipped with mercury loss-of-head gages, which showed the head loss through the sand and gravel only.

On all the filters described the mercury loss-of-head gages were read at least every 2 hours, and in most cases they were read hourly. Filter runs were defined as the length of time in hours required to reach a total loss of head of 8 ft. In computing the averages of the filter runs, weighted averages were used; that is, instead of recording filter runs on the day they began or terminated, the run length was recorded on each day during that run in order to indicate the filter-run tendency for that day. This is of importance only during times when there is a wide variation in the lengths of filter runs. The initial loss of head varied directly with the rates of filtration. The sands used throughout these tests were obtained from Muscatine, Iowa, and samples taken from the filters showed that they varied less than 6 per cent in "effective filtration size." The effective sizes ranged from 0.459 to 0.486 mm., as determined by the Baylis method (*Waterworks and Sewerage*, May, 1934, p. 162), or from 0.495 to 0.515 min., as determined by the Hazen method.

There was negative pressure in the filter bed during the latter parts of the filter runs, but very little air binding took place. The water applied to the filters was subjected to various treatments, but each filter received water treated exactly like that applied to the others. Except for rate of filtration, all filters were operated in the same manner.

Four of the steel filters were operated at different rates of filtration for a period of fourteen months. Table I shows the results of this experiment.

TABLE I—CLOGGING RATES OBSERVED AT VARIOUS RATES OF FILTRATION, STEEL FILTERS, 1928-1929

Date	1.6 g.p.m. per sq.ft.	2.0 g.p.m. per sq.ft.	2.4 g.p.m. per sq.ft.	2.8 g.p.m. per sq.ft.
Oct., 1928	.411	.505	.529	.604
Nov., 1928	.490	.615	.784	1.013
Dec., 1928	.368	.407	.511	.592
Jan., 1929	.460	.582	.739	1.003
Feb., 1929	.227	.272	.356	.501
Mar., 1929	.248	.295	.364	.502
Apr., 1929	.489	.587	.721	.967
May, 1929	.304	.344	.444	.682
June, 1929	.353	.469	.649	.978
July, 1929	.360	.462	.576	.813
Aug., 1929	.414	.517	.544	.804
Sept., 1929	.290	.396	.498	.623
Oct., 1929	.125	.164	.224	.269
Nov., 1929	.099	.110	.172	.215
Aver.	.331	.409	.508	.684
Average of filter runs hours	25.8	20.1	15.4	11.3

In 1932, four of the steel filters were again operated at various filtration rates for a period of 5½ months. Table II gives these results.

TABLE II—CLOGGING RATES OBSERVED AT VARIOUS RATES OF FILTRATION, STEEL FILTERS, JAN. 5, 1932, TO JUNE 16, 1932

Rate of filtration in g.p.m. per sq.ft.	2.0	2.5	3.0	3.5
Aver. clogging rate, feet per hour	0.214	0.336	0.393	0.468
Average of filter runs, hours	33.58	20.75	17.25	13.86

Starting in December, 1931, the six glass-tube filters were operated at six different filtration rates for 2½ months. The results of this experiment are recorded in Table III.

These results are not completely consistent. The relationships vary from month to month, and the general averages will not fit exactly any simple mathematical relationship. Although these filters were kept as clean as was practicable, some mud balls formed and some slight cracking of the sand surface and pulling away from the side walls occurred.

Fig. 3 shows the relation between the clogging rate and the rate of filtration. The solid curved lines probably represent the true relationship. It is apparent that the clogging rate is not directly proportional to the rate of filtration at Chicago. The dashed line shows the data of Hulbert and Feben, observed

TABLE III—CLOGGING RATES OBSERVED AT VARIOUS RATES OF FILTRATION, GLASS-TUBE FILTERS, DEC. 4, 1931, TO FEB. 21, 1932

Rate of filt. in g.p.m. per sq.ft.	1.0	2.0	3.0	4.0	5.0	6.0
Aver. clogging rate, ft. per hr.	0.156	0.268	0.485	0.606	0.896	1.173
Aver. of filter runs, hours	48.2	26.1	13.4	9.90	6.13	4.26

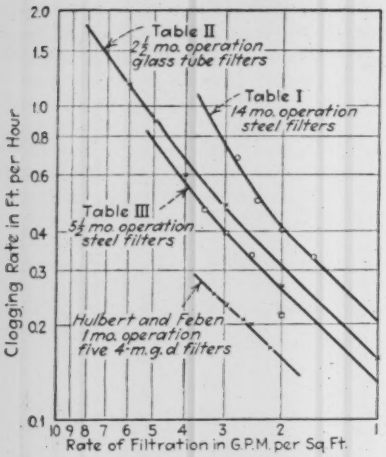


FIG. 3—EFFECT of rate of filtration on clogging rate.

at Detroit, which did display that proportionality (see *E.N.R.*, Oct. 4, 1934, p. 423).

The disproportionality may possibly be explained by the fact that flocculated matter penetrates to different depths in the filter beds. It is known that after the flocculated matter is caught in the filter, the water is gradually squeezed out of it. When a large amount of clogging matter is applied to the filter, either because of high filtration rate or because of its high concentration in the water, there is not time for the coagulated material to compact.

Fig. 4 is a similar plotting of rate of filtration against lengths of filter runs. The dotted straight lines fit the data fairly well through the range of filtration rates likely to be used—namely, from 2 to 4 g.p.m. per sq.ft. These lines represent the equation:

$$H = \frac{K}{I^n}$$

in which H is the hours of filter runs and K is a constant. A value of 1.5 for n seems to fit the Chicago data quite well. This relationship has been checked against the monthly averages and fits them with equal accuracy.

It is obvious that these data show as consistent a relationship between filter runs and filtration rate as between clogging rate and filtration rate. Hence it is concluded that for any one plant the length of filter runs is as good a criterion of filter performance as the clogging rate. For comparison of the operation of various plants, the clogging rate may be a good index, and it should be investigated further.

The relationship given above, it is to be noted, is for a constant settling time. In most plants, increasing the rate of filtration reduces the time of settling; hence this equation would not hold exactly in the ordinary operation of most plants. No data are available to show what the effect of varying the settling time would be. It is probable that the effect of changing the settling time in inverse proportion to the rate of filtration would simply increase the exponent n in the formula to a value of approximately 2.

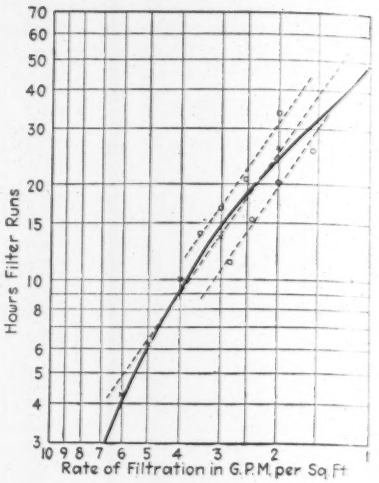


FIG 4—EFFECT of rate of filtration on filter runs.

The writer is indebted to John R. Baylis, physical chemist in charge of the Chicago experimental filtration plant, for guidance and suggestions in this study.

Letters to the Editor

How Wide Is a Roadway?

Sir—Curb widths are probably inherited. Possibly the hubs of stagecoach wheels projected 5 in. beyond the tires, and some builder concluded that a 6-in. timber would prevent the hub striking a wall or bridge member or railing. So today a curb 6 in. wide, or "preferably 9 in. wide," is accepted as standard. The reasonableness or rationality of such custom may be questioned.

For a bridge for two lanes of traffic, without sidewalks, a width of 24 ft. between curbs and 25 ft., or at most 25½ ft. between railings, or between trusses, would be accepted as good practice, with corresponding arrangements for multiple lanes of traffic. It is a pertinent question whether such proportioning is most desirable for traffic and most economical, or whether a roadway is as wide as its width between curbs or as its width between railings.

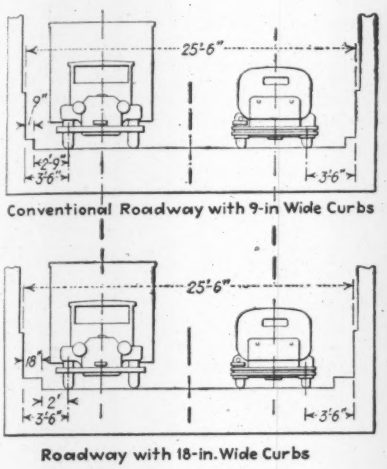
Traffic behavior suggests a different arrangement. The varied roadway conditions of many viaducts and bridges in Kansas City afford opportunity for some interesting observations of the habits and customs of drivers. The 23rd St. Viaduct, somewhat more than a half mile long, has a 6-ft. sidewalk on one side of the roadway and a 6-in.-wide curb backed by a substantial concrete railing on the opposite side. Traffic moves at speeds up to 30 m.p.h. and under usual conditions elects to drive with the nearest wheel track on the sidewalk side of the roadway about 18 in., and not infrequently 12 in., from the face of the curb. On the opposite side of the roadway the nearest wheel track is ordinarily 36 in., occasionally 30 in., from the face of the curb, correspondingly 42 and 36 in. from the concrete railing. The Sixth St. Viaduct, more than 1½ miles long, has no sidewalks. Curbs are 6 in. wide backed by heavy pipe railings 4½ ft. high above the roadway, with rather massive cast-iron posts 8 ft. on centers. Traffic is frequent and rapid. Here, too, the nearest wheel track is ordinarily from 36 to 42 in. from the face of the railing. On the Twelfth St. Viaduct, also of considerable length and carrying frequent and heavy traffic, the wheel tracks along the curb at the sidewalk are generally about 12 in. and sometimes less from the face of the curb. On the opposite side, adjacent to a ballasted-deck streetcar area, the normal tracks appear to be around 18 in. from the curb, but here there is no railing barrier and only occasional trolley poles set about 9 in. back from the curb face.

The Pennsylvania Ave. Viaduct has a roadway 60 ft. wide with wide sidewalks. There are no marks to separate traffic lanes; and while traffic tends to scatter, more than four cars abreast are rarely seen. The normal wheel tracks appear to be 4 to 5 ft. from the curbs. Except for controlled and directed traffic, or as a continuous part of the wide trafficway, or where property alongside can be developed with buildings fronting on the structure, the advantage of the investment in such very wide structures may be questioned.

For the usual roadway widths it seems to be obvious that the high barrier alongside is taken by the ordinary driver as a guide for location rather than the curb. One can demonstrate this for oneself by driving at a road speed of 40 to 50 m.p.h. alongside a brick wall or similar barrier. It is safe to prophesy the driver will not choose to drive so near to the wall that his path would be changed if there were a curb projecting 1 or even 2 ft.

The conclusion seems inevitable that the usable width of a roadway for moving traffic on a structure without sidewalks is not the width between curbs, but, within some limits, the width between railings or other high barriers. It thus follows that for a given width between railings or high barriers a narrowed roadway between wide curbs will afford the same traffic facilities as a wider roadway between narrow curbs would give.

The writer's firm first used an 18-in.-wide curb on the Dumbarton Bridge across San Francisco Bay, built in 1925, where it was adopted purely as a safety footpath, with a roadway 23 ft.



SKETCHES illustrating contention that traffic follows same path between high barriers 25½ ft. apart, whither a 24-ft. or a 22½-ft. roadway is used.

wide between curbs. Later it was used on other structures, and in time the conclusion developed that, with such a curb width, rational analysis of traffic movement made reasonable and logical some reduction in widths between such curbs for traffic facilities equivalent to the more conventional arrangements. Thus, for a structure 25½ ft. between railings or similar high barriers the width between curbs would be made 22½ ft. For fairly long spans such a roadway affords a saving in cost of $4 to $5 per lin.ft. of structure, as compared with a roadway 24 ft. wide between two 9-in.-wide curbs.

Not only does such an arrangement have every *used* width of roadway as the conventional arrangement, but the wide curbs afford safety footpaths. A correct height for such curbs would seem to be not above 10 in. Greater heights make them the obvious barriers or guides from which traffic would choose to keep back a safe running clearance. This is noticeable on the New Jersey high line viaduct, where the curbs are about 18 in. high as well as about 18 in. wide. They seem to affect traffic as a "high barrier" from which the driver keeps his distance, leaving a fairly wide strip of unused pavement alongside. Almost any driver will drive closer to a 10-in.-high curb than to an 18-in.-high curb, especially with the low-swung passenger automobile of today.

These observations are submitted for discussion. They have to do only with long structures. The problems of the short bridge are frequently quite different.

Kansas City, Mo., March 5, 1935.

ERNEST E. HOWARD,
Consulting Engineer.

Private Engineering in Jeopardy

Sir—Since the arrival of the first settlers on American soil the world has watched with interest and often with admiration the accomplishments of the creators of this new world. Perhaps we can justly take greatest pride in what has been done in the oldest of man's arts—the art and science of providing shelter from the rigor of seasons and the vicissitudes of the weather. Our buildings are the outstanding and enduring monuments that attract the awe and admiration of mankind. In the field of building construction our success has far surpassed anything that can be claimed for any people in any age of history.

In the last century progress has been as rapid as the results have been tremendous. It is due to a rare combination of art and science, individualism and ingenuity. And the modern structure is a most complex affair; too complex indeed for any one human to master the intricacies of but a few of its component parts. Even in the design of a one-family dwelling, the architect, who has become the coordinator (where in past ages he used to be even the actual constructor) cannot get along without the cooperation of experts in electrical and mechanical work. When it comes to larger public buildings he must gather a group of competent consultants who are thoroughly versed in such specialties as foundations, structures, heating, ventilating, lighting, plumbing, etc.

Any one of these subjects has required the dedication of a man's career to its mastery. Every community has become equipped with offices of practitioners, specialists, consultants—call them what you will—to supply its need for talent in times of normal activity. There has been a vast network of such responsible organizations spread over the country. There has been proper competition between the units, and this system has undeniably resulted in the marvelous accomplishment upon which we as a people most justly pride ourselves.

Today we are in a pause. Private interests are making no demands upon this web of consultants, which includes architects, engineers and builders. If, some night that web were destroyed or seriously torn apart, it would hardly be noticed on the following morning. But we look forward to a day when our normal activities will be resumed. Our government is professing to do all that it can to help the people through this fog. What is it doing to preserve this web? This web is a fabric—knotted in the various communities by personal contacts born of association on jobs done—dependent upon knowledge of local conditions and markets. It is a living thing that has grown like a healthy vine, replacing its dead leaves with new growth, feeding itself upon its fallen fruit and sending out its new sprouts and shoots to cover the barer spots.

The government through the Procurement Division of the Treasury Department, for instance, is threatening to destroy this web as it has existed and so successfully functioned in the past. The country will not thank the Administration if we find as we emerge from the depression that our talents have been completely disorganized, disrupted and dissipated.

To be specific: the government is undertaking a program of building construction. By creating a large salaried staff in Washington it is attempting to design and direct for this program. The cream of the profession is being left to starve in empty offices in every other city. How is private enterprise going to find itself equipped to take up the normal life if all we have left is a huge bureau composed of the men who were the first to be unemployed and who, spurred by desperation, traveled to Washington to get jobs? This is what will happen soon if our trained, competent and responsible enterprising professional men are given no consideration, while everything is being done for the many who carry a hoe, a hod and a vote.

Building construction is a special field. We among nations are acknowledged leaders in that field. Our system must have been the best for this to be true. Because for the moment we are not using our system to the full we should be more than careful to keep the essential vital parts of the machine in repair. The duty of our government is as clear in this case as it is to see that in a land where there is no scarcity of food no individual human should be permitted to go hungry. Department heads should be prevented by mandate from tampering with and perhaps doing irreparable harm to our national institutions. What may appear in their eyes to be timely economy and efficiency may well prove to be the utmost folly. The lost ranger would only as a last resort cut off his horse's leg that he might eat.

JOHN W. PICKWORTH,
Chairman, Committee on Engineering Service for Federal Government Projects, New York Chapter—Society of Professional Engineers.

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April 11, 1935

Recovery Possibilities

AFTER three months of active debate and negotiation, the works bill has at last been passed by Congress. It remains, as it was in the beginning, a composite relief and recovery measure. That it will provide much salutary activity of work-relief character is certain; Harry L. Hopkins' connection with its application gives assurance of a campaign at least as effective as the CWA campaign of a year ago. So far as recovery is concerned, however, the value of the new act depends but little on its terms and almost wholly on its administration. If speed and intensive simplification of procedure are achieved, and interference with private and local initiative is avoided, it can do much to hasten economic recovery. This applies to the constructive normal projects which the measure includes. Work-relief operations cannot help to prime the pump; they merely build morale and keep matters from getting worse while other factors are pushing ahead along the recovery road. But the $800,000,000 fund for roads and grade-crossings and the $900,000,000 allotment for non-federal works are powerful means for stimulating revival of industrial activity. Unquestionably the road and grade-crossing construction will go into action promptly. The non-federal allocation can be made equally rapid if handled under an aggressively liberalized policy. Indeed, the $900,000,000 may easily be multiplied several times if the grant method prevails and if local governments cooperate energetically and utilize the private money market. In that case the non-federal works can be made a truly effective primer.

Private Capital Comes Out

ONE OF THE ITEMS in the work-relief bill which has been acclaimed in some quarters is the $450,000,000 earmarked for housing. However, uncertainty as to what type of housing is contemplated and the possibility that expenditures will be slow make the contribution of this item to present business recovery highly problematical. A much more hopeful sign is the apparent disposition of large mortgage lending agencies to cooperate with the Federal Housing Administration on its insured mortgage plan. Especial commendation is due the New York Life Insurance Co. for the $5,500,000 loan it made under this plan last week for a large housing development in Brooklyn. Similar action by other organizations that normally loan large sums for new construction would be unusually beneficial. Most of them have had to take over and operate so many defaulted properties that there has been little desire to make additional real estate loans. Furthermore, courage to liquidate properties now held and to re-invest the proceeds in new construction has been lacking. Nevertheless, something approximating such procedure must be done if housing is to contribute in major degree to business improvement. The Brooklyn loan may be a harbinger of change and improvement. If private capital in large amount should suddenly decide to embrace the advantages of the FHA mortgage lending plan, priming of the business pump might easily be accomplished without recourse to any abnormal federal expenditures, and a strong start would be made toward normal action in filling the housing deficit.

Twice the Record

BY THE FORCE OF OLD HABITS, taught by many a disastrous flood experience, engineers engaged in dam design often follow the rule of proportioning their spillways to carry a flood twice as large as the greatest on record. The habit reflects a desire to be conservative, yet its conservatism is in doubt. If the variability of records be kept in mind, as well as the inadequacy of hydrologic experience in even the fullest record, it becomes evident that the seemingly generous margin often is insufficient. The risk is greatest in the case of small streams, where flash floods and cloudbursts have to be reckoned with, where records are likely to be faulty, and where the small size of the work may cause the engineer to take too much for granted. It is therefore well to remember that the 100 per cent allowance in flood volume is wholly empirical, and that the twice-record flood rule is strictly a factor of ignorance. Only after the most thorough search for evidence of past flood stages and volumes is the engineer warranted in applying a conventional safety factor. The gradual crystallization of rule-of-thumb practice, which always involves the danger of casual application to inadequate data, is nowhere so dangerous as in the field of dam spillways, and the young engineer in particular will be well advised to look on a rule of this kind with ever-alert suspicion before he applies it to his work.

A Tunneling Classic

TO THE ENGINEER who lacks personal contact with tunneling operations, such work often appears to be rigidly routinized, limited in its technical methods as well as in its economy by the severity of the demands upon it. In actual truth the tunnel builder's art draws on a remarkably high type of ingenuity, resourcefulness and foresight. This is exhibited in every major tunneling enterprise—just at present in the driving of the Colorado River Aqueduct through the San Jacinto Mountain, in the New York Midtown Tunnel, in the great diversion tunnels at Fort Peck, and perhaps most strikingly in the just completed Baltimore tunnel of the Pennsylvania Railroad. The last-named work, because of its size as well as the imperative necessity of preventing ground movement, brought into play that originality of engineering attack which arises from thorough command of all available expedients joined to creative resourcefulness. The result, the three-shield construction system devised and successfully carried through, ranks this undertaking as a classic contribution to tunnel-driving history. Far from being inordinately costly, this elaborate procedure proved to be cheaper than open-cut work—excellent proof of the power of methods and equipment brought into being by wide experience in the art. It may be concluded that even in the face of the large resources available to the modern contractor for open excavation work, tunneling promises not only to hold its place but, as current activities show, to find increasing use in competition with open construction.

Developing Superhighways

IT IS QUITE APPARENT to anyone who looks forward to the coming days of road transportation that in future years the concentrated long-distance traffic from east to west or north to south will move over a great network of express roads markedly different from the main roads of today. The traveler of that time will find the joint advantages of safety, capacity and convenience—and will find also, at many points, the attraction of scenic beauty. He will experience as a reality what up to now is barely more than an ideal, the close interconnection of our forty-eight states toward which the efforts of three decades of roadbuilding have been directed. Transportation service will be of a character so far beyond that which we know today as to give full warrant for calling these roads "superhighways."

The name has already become familiar. It is used today to denote the forerunners of the future express roads, the sections of multi-lane road that are progressively linking up our major population centers. For the requirements of today these main links are excellently designed; they testify to the intelligent study that highway engineers have devoted to road-traffic customs and conditions. But in looking to their future development it is essential to keep in mind the rapid rate at which change in road-service condition is carrying us forward. The progress of the last half-dozen years, reflected in the road planning and standards of today, testifies to the rapidity of this change; and it is certain to find repetition in equally great progress during the next decade and more. Even the most superficial study of road conditions, whether directed to safety, to time efficiency or to cost, reveals so many deficiencies in the best of our present-day roads that it can leave no room for doubt as to the extent of further improvement.

We may foresee, also, that this improvement will be a matter of gradual evolution, quite like the improvement accomplished in the recent past. Today's knowledge is not adequate to fix the elements of the future perfected express roads. Moreover, it is inevitable that these elements will be dictated by the demands of future vehicles, probably differing in many ways from those now in use, and by the operating conditions, both physical and economic, to which changing habits will give rise. Even the most painstaking advance calculation of these requirements is subject to a large margin of error. Particularly is this true in economic respects. Only experience can show how large a part of highway transportation desires to use and is willing to pay for a superhighway network.

In view of such conditions it is idle at this date to propose an immediate beginning on the construction of a superhighway system. The problem still lies in the future. Nevertheless, the suggestion of definite projects, even though it be but long-range thinking, has the merit of giving expression to a coming necessity and of pointing to the desirability of considering now the essential preliminaries that must govern planning.

And for the same reasons it is well to be clear as to the nature of some of the questions that require answer before superhighway planning can become definite. There are many, for the subject as yet is little advanced beyond its primitive state. We have built up to now only about 1,500 miles of four-lane highway, and this, in large part, to meet urban rather than intercity requirements; experience in the operation of these roads is correspondingly limited. Study of the practices embodied in their construction shows clearly that expert judgment continues to diverge widely not only on pavement structure and smoothness but on such basic points of design as width, alignment, curvature, grades and profile, as well as on laning, traffic practices, signaling, intersections, turnouts and other provisions for safety and convenience.

Consider one of the most recent examples of trunk-line road construction, the great highway in Connecticut paralleling the historic Boston Post Road, recently described (*ENR*, March 14, 1935, p. 386). No road yet undertaken equals this one in its combination of planned length, large traffic width and solidity of surfacing. Yet, are we ready to say that this road will meet all the requirements of superhighway traffic likely to exist ten or a score of years from now? Far from it! Indeed it is more than likely that, when the second 40 miles of this road comes to be designed, the engineers of the present first section will find occasion for extensive revision. No forecast of possible traffic developments justifies any other conclusion.

It follows that intensive study of major highway service must be carried out before we can hope to have adequate and yet flexible standards to guide in superhighway design and construction. It is in developing the greatly increased knowledge required before effective superhighway construction can begin that the engineers of the present road organizations have one of their greatest opportunities.

For Community Safety

DUE LARGELY to the neglectful attitude toward water-supply service that has been displayed during the depression years, many an American community today is facing a serious, though unrecognized, hazard to its safety. Distribution-system maintenance has accumulated an alarming deficit; replacement of obsolete or worn-out equipment has been deferred year after year; system enlargement has been delayed regardless of the imminence of greatly increased demand. More than once, a minor mishap in system operation has turned into a major accident through the failure of some neglected element to function.

All this is no new story to the capable and earnest waterworks men who have struggled valiantly during recent years to stretch a meager budget to keep the systems under their charge in satisfactory functioning. The public at large, however, does not realize that niggardliness toward water supply cannot continue without endangering the very existence of sound community life. The financial needs of water service must be made evident to the community if the hazards of pollution, depletion or critical interruption are to be avoided.

Responsibility for this process of education rests on the waterworks man himself, for no one else is competent to state the case. But organization for the purpose is essential if the effort is to be effective. Only through the strength of union in such organizations as the American Water Works Association can the voice of the informed waterworks man claim the attention of his community and induce it to insure itself against failure of its most essential supply. The water engineer or manager has no more obvious responsibility to his service than to utilize that strength of organization and increase it further by his own active support.

CURRENT NEWS

President Signs Work Relief Bill; Starts Allocating

WHILE on the special train taking him from Jacksonville, Fla., to New York City, on April 8, President Roosevelt signed the $4,880,000,000 work relief bill which was passed by Congress on April 5.

Upon approving the measure, the President announced the immediate allocation of $125,000,000 for continuing emergency relief; $30,000,000 for continuance of the CCC; and $842,000 for similar work on Indian reservations.

$4,000,000,000 of new funds

The bill as finally approved by both Houses of Congress states the purpose to be "to provide work relief, and to increase employment by providing for useful projects." To attain these ends there is appropriated $4,000,000,000 of outright new funds, $500,000,000 from unexpended balances of the RFC, and $380,000,000 from previous PWA, CWA, and other emergency appropriations, making an aggregate appropriation of $4,880,000,000.

The new law provides first that whatever part of the appropriation the President considers necessary will be used for continuing relief and, second, that the PWA funds which have during the past few months been diverted to relief purposes, may be restored to the PWA.

Allocation of funds

The main body of the fund appropriated is then allocated to the following classes of work:

(A) Highways, roads, streets and grade crossing elimination, $800,000,000;

(B) Rural rehabilitation and relief in stricken agricultural areas and water conservation, trans-mountain water diversion, irrigation and reclamation, $500,000,000;

(C) Rural electrification, $100,000,000;

(D) Housing, $450,000,000;

(E) Assistance for educational professional and clerical persons, $300,000,000;

(F) Civilian Conservation Corps, $600,000,000;

(G) Loans or grants, or both, for projects of states, territories, possessions, including subdivisions and agencies thereof, municipalities, and the District of Columbia, and self-liquidating projects of public bodies thereof, where, in the determination of the President, not less than 25 per cent of the loan or the grant or the aggregate thereof, is to be expended for work under each particular project, $900,000,000;

(H) Sanitation, prevention of soil erosion, prevention of stream pollution, sea coast erosion, reforestation, forestation, flood control, rivers and harbors and miscellaneous projects, $350,000,000.

This allocation is made somewhat flexible by the provision that "not to exceed 20 percentum of the amount herein appropriated may be used by the President to increase any one or more of the foregoing limitations if he finds it necessary to do so in order to effectuate the purpose of this joint resolution."

Further provision is made "that no part of the appropriation made by this joint resolution shall be expended for munitions, warships, or military or naval matériel; but this proviso shall not be construed to prevent the use of such appropriation for new buildings, reconstruction of buildings and other improvements in military or naval reservations, posts, forts, camps, cemeteries, or fortified areas, or for projects for non-military or non-naval purposes in such places."

Funds for highway construction

Funds allocated for highway construction are apportioned to the states in accordance with the Hayden-Cartwright Act of last year. The law also provides that funds used for grade crossing elimination are to be proportioned to the mileage of highways, mileage of railroads and population. It is further provided that the expenditure of these funds by state highway departments is to be in accordance with the federal highway act of Nov. 9, 1921, as amended, and the Hayden-Cartwright Act of June 18, 1934. However, no part of the funds need be matched by the states.

Further provisions are made that the highway funds shall be spent under rules and regulations prescribed by the President, that preference in employment of labor shall be given to persons receiving relief, excepting those in executive, administrative, supervisory and highly skilled positions; that the President is authorized to predetermine for each state the hours of work and the rates of wages to be paid skilled, intermediate and unskilled labor; and that whenever practicable full advantage shall be taken of the facilities of private enterprise.

Rivers and harbors work

Rivers and harbors projects, reclamation projects, and public building projects are to be carried out under the direction of the respective permanent government departments or agencies now having jurisdiction of similar projects.

Funds are made available by the President for making loans to finance, in whole

(Continued on p. 537)

Contract for Gate Structure of Fort Deck Dam Spillway Let

A contract for the construction of the spillway gate structure, cutoff, and appurtenant works at Fort Deck Dam was let by the district engineer's office, U. S. Army, Kansas City, Mo., on April 4, on a combination bid of $3,985,424 by the firms of Fielding & Shepley, Inc., and Addison Miller, Inc., of St. Paul, Minn. Other bidders were Spillway Builders, Inc., Kansas City, $4,387,426; G. L. Tarlton, Inc., and Frazier-Davis Construction Co., St. Louis, $4,779,145, and Six Companies, Inc., San Francisco, $5,147,797.

Contractors Meet To Plan Work Under Relief Act

THE governing and advisory boards of the Associated General Contractors of America will hold their annual spring meeting in Washington, May 2-3, to lay plans for the expeditious handling of their industry's part in the $4,880,000,000 work relief program.

Representative contractors from the building, highway and heavy construction and railroad divisions of the industry will participate in the meeting, which will give detailed attention to the question of facilitating contract methods in each of the various construction fields included in the Emergency Relief Appropriation Act. Nick F. Helmers, of St. Paul, president of the association, will preside.

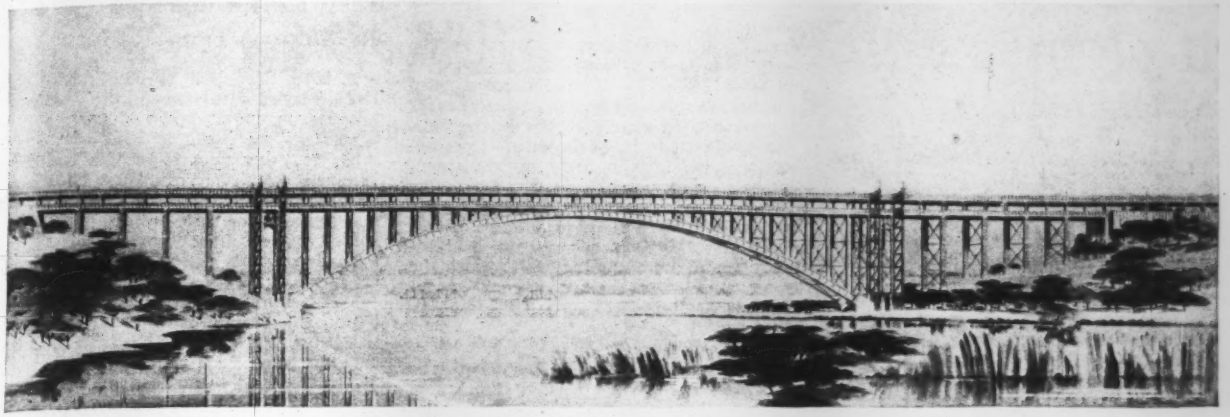
Contractors believe that a major portion of the construction phases of the program will be executed under contract in view of the provision in the measure that full advantage shall be taken of the facilities of private enterprise in the carrying out of the work. The board will exert every effort to see that this is done.

E. J. Harding, managing director of the contractors' association, in announcing the call for the governing and advisory boards meeting, expressed the belief that under the impetus of the work relief measure the coming summer will witness a banner season in all lines of construction. He pointed out that the fund, as earmarked in the bill, will provide, in itself, a well-rounded volume of building, highway and heavy construction projects. Mr. Harding also was optimistic as to the prospects of revival in private residential construction, and declared that the board would give special attention to the small home builder at its May meeting.

The meeting will follow immediately upon the conclusion here of the twenty-third annual meeting of the United States Chamber of Commerce, which will be attended by many of the contractors including their past-president, A. P. Greensfelder, of St. Louis, who is a director of the construction and civic development department of the Chamber.

Registration of Civil Engineers Proposed in State of Illinois

A bill has been introduced into the general assembly of Illinois which calls for the abolition of the examining committee for structural engineers and provides for the appointment of an examining committee for civil engineers, one to be a professor in the civil engineering department of the University of Illinois and the remaining five to be specialists engaged in either structural, highway, sanitary, or hydraulic engineering or city planning. At the present time only structural engineers are licensed in Illinois.



PROPOSED HENRY HUDSON PARKWAY BRIDGE FOR WHICH BANKERS HAVE PURCHASED BONDS

Construction of the new parkway in New York City linking Riverside Drive, which now ends at Dyckman St. (about 206th St.) with the Sawmill River Parkway in Westchester County was assured last week when a bank syndicate purchased $3,100,000 4-per cent bonds of the Henry Hudson Parkway Authority. Starting with a grade elimination bridge at Dyckman St., the new parkway will extend north to the Harlem River ship canal which will be crossed by the high level arch bridge illustrated above. North of the canal the parkway will follow the general line of the Spuyten Duyvil Parkway to Riverdale Ave. near the southwest corner of Van Cortlandt Park. The New York state department of public works is building a new road from this point north through the park to the Sawmill River Parkway terminus.

The Harlem River ship canal crossing is to be an 800-ft. hingeless steel arch carrying a 42-ft. roadway and one sidewalk. The two-box girder arched ribs spaced 50 ft. center to center are of plate-girder construction 12½ ft. deep and 3 ft. 8 in. wide. They will be made of silicon steel. The arch has a rise of 120 ft. and provides a clearance of 140 ft. over the ship canal. Although the bridge is designed for two decks, only the lower deck will be built initially. The consulting engineers for the arch bridge are Robinson & Steinman, while the consulting architect is Aymar Embury, II. Waddell & Hardesty are consulting engineers for the grade separation structures along the parkway, and Madigan & Hyland are consulting engineers in charge of specifications and construction. Gilmore Clark is landscape architect.

The Henry Hudson Parkway Authority was created early in 1934 by act of the state legislature. In effect it is a division of the New York City department of parks with authority to issue revenue bonds to be retired through tolls charged for the use of the facilities constructed with the bond sale proceeds. Robert Moses is commissioner of parks, and W. Earle Andrews is superintendent of parks. It is planned to charge a 10-cent toll on the new bridge, which studies indicate will provide gross revenues in the first year of operation of something over $350,000.

Speculative Builders Oppose Construction Code

Protest against the application of the construction code to house building is made by the National Association of Real Estate Boards in a statement which has just been filed with the Senate finance committee which is investigating the operations of NRA. No appearance before the committee has been accorded this group, but the statement filed was widely disseminated during the past week.

The association requests the committee to report to Congress that the construction code should be abrogated, or that in any event the business of developing building sites or the building of residential houses should not be considered under the construction code. The code is declared to be adverse to public interests in that it has increased costs, discouraged new construction and decreased employment. It is claimed that there were some evidences of recovery in house building in 1933, but in the fall of that year, when the construction code seemed assured, prices of building began to increase rapidly, and 1934 witnessed an all-time low point in new family accommodations. It is claimed that the average cost of a small house today is approximately 30 per cent greater than it was 2 years ago, and that price increase due to codes has offset the benefits of other laws passed by Congress.

It is stated that a code for the Land Development and Home Building Industry has been pending for some months, and meanwhile the provisions of the construction code, except as to labor provisions, have been stayed for members of the former industry.

A separate code for the Land Development and Home Builders Industry was heard at public hearing nearly 10 months ago on June 14, 1934. The industry was defined as the development of land as building sites and sale or lease thereof, and the building of 1 and 2-family homes for purposes of sale or lease, including maintenance, remodeling or repair.

The separate code was vigorously protested by other elements of the construction industry and it was declared that it would destroy the integration of the construction industry if the building of 1 and 2-family houses was separated from the unified industry.

Since last June, there have been successive periods of activity and inactivity on behalf of a separate code. Meanwhile, the partial stay against the construction code has remained in effect since it was granted, pending determination of the application for a separate code. This has brought forth protests periodically from within the construction industry, and possibly the vigorous manner in which the issue has been brought out by the real estate interests may serve to expedite a decision on the controversy.

The operative builders represent only a small percentage of the total volume of residential construction for the only year in which complete figures are available.

The association's statement by inference seems to place all responsibility for any increase in house construction costs since early 1933 upon the construction code, although this code does not govern the production and sale of building materials; nor does it seem to take into account the fact that decreased demand more than building costs may have controlled the activities of operative builders.

Long Tunnel Holed Through On the Colorado River Aqueduct

Wide Canyon Tunnel No. 1 on the Coachella division of the Colorado River Aqueduct, Metropolitan Water District of Southern California, was holed through on March 27. The crews working from Thousand Palms Camp and Wide Canyon Camp met near the center of the 3-mile long tunnel with a variation of less than a quarter of an inch in the centerline.

Wide Canyon Tunnel No. 1 is one of eight tunnels on the Coachella division totaling 33 miles in length. Work on this division is being done by the forces of the metropolitan water district. In all there are 92 miles of tunnel on the aqueduct system.

Passenger Train Electrification Completed on the Pennsylvania

Conversion from steam to electric operation of the entire through and local passenger service on the Pennsylvania Railroad between New York, Newark, Philadelphia and Washington was completed on April 7. The changeover has been in progress since Feb. 10.

The completely electrified passenger service embraces 639 daily trains, of which 191 are through trains drawn by electric locomotives and the others are multiple-unit types.

Electric operation of the freight service between Washington and New York is expected to be initiated within the next few weeks and will include 47 through trains.

Annual savings of $7,500,000 are expected from the electrification.

New Works Program To Get Under Way At High Speed

Washington Correspondence

WITH the $4,000,000,000 appropriation in President Roosevelt's hands, the new work relief program, held up for nearly three months in Congress, will soon be under way. Increasing millions have been dissipated for direct relief and PWA has idled while the Senate jumped from one controversy into another before finally giving the President practically unlimited authority to spend as he sees fit the largest peace-time appropriation in history.

Speed is the criterion of the new program. This may present a sharp contrast to PWA's deliberate procedure which has put $2,000,000,000 worth of work under contract in two years but the rate of speed at which the new work actually progresses will not be apparent for several weeks. With the spring season already at hand, any further delay will deprive the Administration's new drive for recovery of its quick, stimulating effect. The PWA program has demonstrated that delay at the outset can never be overcome.

Reserve fund possible

It is expected that, initially, the President will deduct 20 per cent from all allocations made by Congress to create a reserve fund of $800,000,000 to be distributed later among the various types of work which show the greatest capacity for providing the most employment in the shortest time. If the administration's objective is realized 3,500,000 persons will be employed on work relief projects within a year; about 2,500,000 are now so employed under state emergency relief administrations.

The federal administration will press its policy of returning the burden of supporting unemployables to the states and local communities but this division of responsibility probably will not be accomplished, if ever, until late in the year. It is expected, therefore, that some part of the $4,000,000,000 fund will be diverted for direct relief as the $880,000,000 of unexpended and impounded funds that were reappropriated by Congress have already dwindled to $500,000,000 to meet FERA's requirements. The money so transferred included $310,000,000 of PWA funds which Administrator Ickes hopes will be restored.

The compromise reached in the Senate-House conference committee on the $900,000,000 allocation for non-federal projects, which requires that 25 per cent of the loan or grant, or both, made for any project, shall be spent for "work," will not raise any obstacle to undertaking heavy construction of the character previously financed by PWA. This broad limitation was adopted when the Administration objected to the provision written into the bill by the conference committee which would have disqualified any project that did not embody 30 per cent of its cost in direct labor.

The allocation of $800,000,000 for highways and grade crossing elimination includes $100,000,000 carried by the Agriculture Department appropriation bill for the next fiscal year that was authorized in 1934; 75 per cent of this authorization has been obligated. While the balance of $700,000,000 is subject to increase or reduction at the President's discretion, the proportion to be allocated for highways—probably $400,000,000, will be apportioned among the states in the usual manner for expenditures by state highway departments. The allotment to be made for grade crossings will be apportioned among the states, one-half on population, one-fourth on the mileage of the federal-aid highway system and one-fourth on railroad mileage. Most of the state highway departments have already completed plans that will absorb the entire amount of their share for grade-crossing projects.

Highways and grade crossings

Out of each $100,000,000 allotted for highways and grade-crossing elimination, the several states will receive the following amounts:

State	Basis of apportionment: Highways[1]	Basis of apportionment: Grade crossings[2]
Alabama	$2,129,000	$2,073,000
Arizona	1,318,000	652,000
Arkansas	1,719,000	1,831,000
California	3,973,000	3,794,000
Colorado	1,742,000	1,362,000
Connecticut	728,000	874,000
Delaware	462,000	221,000
Florida	1,332,000	1,450,000
Georgia	2,559,000	2,522,000
Idaho	1,140,000	870,000
Illinois	4,458,000	5,260,000
Indiana	2,534,000	2,624,000
Iowa	2,560,000	2,865,000
Kansas	2,561,000	2,644,000
Kentucky	1,911,000	1,894,000
Louisiana	1,482,000	1,650,000
Maine	860,000	734,000
Maryland	898,000	1,070,000
Massachusetts	1,673,000	2,110,000
Michigan	3,232,000	3,382,000
Minnesota	2,706,000	2,760,000
Mississippi	1,773,000	1,675,000
Missouri	3,083,000	3,164,000
Montana	1,885,000	1,428,000
Nebraska	1,985,000	1,852,000
Nevada	1,150,000	457,000
New Hampshire	485,000	424,000
New Jersey	1,604,000	2,038,000
New Mexico	1,473,000	914,000
New York	5,665,000	6,930,000
North Carolina	2,421,000	2,490,000
North Dakota	1,470,000	1,702,000
Ohio	3,934,000	4,280,000
Oklahoma	2,349,000	2,383,000
Oregon	1,558,000	1,211,000
Pennsylvania	4,793,000	5,901,000
Rhode Island	507,000	359,000
South Carolina	1,386,000	1,510,000
South Dakota	1,526,000	1,464,000
Tennessee	2,150,000	1,943,000
Texas	6,148,000	5,591,000
Utah	1,061,000	641,000
Vermont	474,000	376,000
Virginia	1,873,000	1,939,000
Washington	1,552,000	1,569,000
West Virginia	1,144,000	1,375,000
Wisconsin	2,474,000	2,578,000
Wyoming	1,138,000	726,000
District of Columbia	487,000	201,000
Hawaii	475,000	237,000
Total	$100,000,000	$100,000,000

[1]Sec. 204 National Industrial Recovery Act; ⅓ Federal aid; ⅓ population.
[2]⅓ population; ⅓ mile Federal-aid highway system; ⅓ mile railroad.

W. C. Markham, executive secretary of the American Association of State Highway Officials, estimates that $1,500,000,000 will be put into highways in the next two years. In addition to the allocation of $700,000,000 carried by the work relief bill, the states will furnish about $480,000,000 for new construction, also several hundred millions for maintenance, for the purchase of machinery, bond retirement, etc.

The rural phase of the new work relief program may be hampered by the very comprehensiveness of the provisions of the new law. Several amendments to include, specifically, the acquisition of marginal land, the prosecution of rural work projects to provide supplementary aid to destitute farmers, and the establishment of rural industrial communities and subsistence homesteads, were rejected by the Senate conferees.

Administrator Ickes has said that the PWA is ready to shift more responsibility to state offices, by setting up in every state in addition to the PWA state engineer, a miniature organization with legal, financial and engineering devisions, recruited from Washington which would expedite the handling of applications and send them with its recommendations to Washington. Ickes said that this would speed up PWA procedure materially.

Ickes denied reports this week that the Passamaquoddy tidal power project in Maine had been approved. That project, he said, has not been before the PWA in final form for months. Asked whether it would receive consideration in the future, he said he is not a prophet.

Blast Kills Three Men In Midtown Tunnel at New York

A blast fired just at the time of shift change killed three men in the Manhattan heading of the Midtown Tunnel in New York City on April 8. One of the victims was the shift superintendent, Fred Mitchell, of New York City. The accident occurred despite regular use of all safety precautions to protect the blasting work, and resulted from an unexplained misunderstanding as to whether the last of the men had left the working face.

The heading in question is on the Manhattan land section of the new vehicle tunnel being built under the Hudson River between New York City and Weehawken, N. J., about on the line of 39th St., New York. Open-cut approach will extend east of 11th Ave., while from a shaft near 11th Ave. to the shore shaft west of 12th Ave. the work is in part-rock tunnel, which is being driven by shield under compressed air because of soft ground in the top of the section. The heading at present is about 500 ft. west of the 11th Ave. shaft; bulkhead and airlock are close to the shaft, and the pressure carried is about 15 lb. The face is drilled and shot before the shield is shoved and the next ring of cast iron lining erected.

At the time of the accident the morning shift was leaving the heading and the afternoon shift was entering. The face had been drilled and loaded, and the outgoing blaster turned over charge to the incoming blaster, who, after repeatedly calling "Fire" and seeing no men left at the shield, closed the firing-line break switch near the shield, walked back and closed the firing switch. However, the superintendent and four men had remained at the shield, it is believed for the purpose of forcing back the jack-operated movable tables of the shield so that they would not be injured in the blast. When the shot was fired, four of the men were injured, three dying shortly afterward. The shield driver, who was in the compartment containing the shield jack and platform jack valves, which is bulkheaded off from the face, escaped.

The tunnel is being constructed for the Port of New York Authority, C. S. Gleim, engineer of construction, by Mason & Hanger Co., under M. I. Killmer, manager, and Howard L. King, resident engineer.

President Signs Work Relief Bill

(Continued from p. 534)

or in part, the purchase of farm lands and necessary equipment by farmers, farm tenants, croppers or farm laborers.

Senate approval of appointees

Any administrator or other officer named to have general supervision over the program and receiving a salary of $5,000 or more per year from the appropriation, and any state or regional administrator receiving a salary of $5,000 or more per year from the appropriation must have his appointment approved by the Senate.

The President is authorized to acquire by purchase or by the power of eminent domain any real property or interest therein and improve, develop, grant, sell, lease or otherwise dispose of it.

Wage rates

The President shall require to be paid "such rates of pay for all persons engaged upon any project financed in whole or in part, through loans or otherwise, by funds appropriated by this joint resolution, as will in the discretion of the President accomplish the purposes of this joint resolution, and not affect adversely or otherwise tend to decrease the going rates of wages paid for work of a similar nature."

However, whenever permanent buildings for the use of any department of the government are to be constructed, the provision of the act of March 3, 1931 (Bacon-Davis Act) shall apply but the rates of wages shall be determined in advance of any building.

"Wherever practicable in the carrying out of the provisions of this joint resolution, full advantage shall be taken of the facilities of private enterprise."

No part of the funds appropriated can be used for the administrative expenses of any department or federal government agency that is ordinarily financed from annual appropriations, unless additional work is imposed by reason of the new law.

The Public Works Administration is continued until June 30, 1937, and is authorized to perform such of its functions under the National Industrial Recovery Act or the new work relief law as may be authorized by the President.

All sums appropriated under the Recovery Act are to be available until June 30, 1937. The President is authorized to sell any securities acquired under the Recovery Act, or under the new law, and all moneys realized from the sale shall be available for the making of further loans under the Recovery Act or under the new law.

Construction Work Starts on Los Angeles Station

Construction work on the new Los Angeles Union Station has been started with the pouring of concrete for a 450-ft. pedestrian tunnel which eventually will be used by railroad travelers to reach trains. About 100 men are being employed on the site in connection with the present work. It is expected that the subway will be completed in about thirty days, when other major construction work on the terminal will start.

Work Stops on Red Bluff Dam

Work on the Red Bluff dam and hydroelectric plant, Pecos, Texas, has been suspended, due to the recent discovery that the foundation of the structure will have to go much deeper than the test holes showed in order to reach sound rock. This does not mean that the project may be abandoned, it is stated by Vernon L. Sullivan, engineer in charge of construction.

Rivers and Harbors Bill Passed by the Lower House

The House of Representatives, on April 9, gave approval to the omnibus rivers and harbors bill. Authorizing the expenditure of some $272,000,000 for 204 waterways improvements projects, the bill is the first of this character to be brought before the House in the last three years. In 1932 a bill which contained 72 of the present projects was passed; but got no further. The last legislation of this kind to be enacted into law was in July 1930.

As indicated in the report of the Rivers and Harbors Committee, of the proposed authorization of $272,000,000 the PWA and the War Department have already allotted $58,067,499 for 77 projects, estimated to cost $105,011,457. These are the only projects to be allotted funds to date.

FHA Insures Large Loan for Housing in Brooklyn

Through the agreement of the New York Life Insurance Co. to make a $5,500,000 mortgage loan and the approval of the Federal Housing Administration of insurance for it, financing of an $8,000,000 housing project in Brooklyn, N. Y., was assured last week. Sponsored by Joseph P. Day, New York real estate man, and Andrew J. Eken, of Starrett Bros. & Eken, well known builders, now engaged in constructing the Hillside Housing development in the Bronx, the new project is by far the largest private apartment enterprise to secure financing since the beginning of the depression.

Beach Gardens Apartments, Inc., recipient of the insured loan, is a limited dividend corporation but unlike other similar companies in New York, will pay full city, state and federal taxes. The project is located on Gravesend Bay, Brooklyn, between Fort Hamilton and Coney Island. It will include eight apartment buildings, each of six stories, containing 5,000 rooms and providing for about 2,000 families. The buildings will cover a tract of 53 acres, 38 of which will comprise a new fill extending out into the bay as far as the pierhead line. The frontage on the bay between 18th and 21st Aves. is about 2,000 ft. The project is adjacent to Bensonhurst Park.

Buildings will be of fireproof construction with automatic elevators and other modern facilities. About 75 per cent of the apartments will be of three and four rooms and others will range from two to six rooms. The rental will be less than $15 per room. Shreve, Lamb & Harmon, the architects for the Empire State Building and other important New York structures, are preparing the plans for the new housing development.

Baltimore to Vote Funds To Finance Public Works

The city of Baltimore may put all or any part of several improvement loans on the city ballot, under the provisions of an act passed recently by the Maryland general assembly. An act passed in 1931 required the voters to pass on the full amount. The loans include $5,000,000 for paving, $5,000,000 for sewer work, $500,000 for court houses, $10,000,000 for schools, and $1,500,000 for conduit construction.

Another law enacted by the legislature authorizes the city to use the remaining $1,150,000, or as much of it as is necessary, of an old construction loan to build a wing to the Baltimore Art Museum.

Revised Mississippi Flood Plan Subject of Extended Hearings

The revised plan for flood control on the lower Mississippi River (*ENR*, Apr. 4, 1935, p. 492) was both favored and attacked in hearings before the committee on flood control of the House of Representatives last week.

Opposition to the proposed Eudora floodway developed at the opening hearing on April 1, after Major General Edward M. Markham, Chief of Engineers, the first witness to be called, revealed that while the intake for the Eudora floodway was limited to 700,000 sec.-ft., the plan still calls for maintenance of a fuse plug levee at the upper end of the Boeuf Basin, and that the floodway in time of a superflood might be required to carry 1,500,000 sec.-ft. of water. The proposed back levee extending up to the Arkansas River would be built to full height to keep this within the new floodway east of Macon Ridge.

Members of the flood control committee showed evidence of opposition to the proposal in the plan that flowage compensation for the land in the floodways be fixed by the army engineers, rather than by court action. The plan calls for payment for flowage rights not to exceed one and one-half times the assessed valuation. Doubt was expressed as to whether such payment would be adequate in view of the fact that farmers would have to build new buildings out of the floodway, in some cases several miles from their land. It also was brought out that the government might find it necessary to protect the bondholders for schools, highways and other public works affected by the floodway.

Conflicting views were expressed as to whether the government should provide trestles for all the highways or for only one major highway across the floodway. The army engineers' plan calls for a trestle for the main highway to Vicksburg.

Discussing conditions further down the river, John Klorer, state engineer for Louisiana, urged that the work of increasing the discharge capacity of the Atchafalaya River be speeded up. He favored the construction of the Morganza floodway and also proposed lowering the level at which the Bonnet Carre spillway would be opened to reduce the flood level above New Orleans. Increasing the discharge of the river above the mouth of the Red River by cutoffs makes it imperative that adequate outlets be provided in the lower section, he said. Mr. Klorer said that he thought the fuse plug levee at the upper end of the Boeuf floodway should be strengthened.

Contractors Warned to Secure Code Certificates on Purchases

The divisional code authority for general contractors has issued a warning to all contractors to secure a certificate of compliance with the code involved from each supplier of materials or commodities entering into construction financed wholly or in part by the federal government. Executive Order 6646 provides that no governmental agency or contractor working for the government shall purchase supplies and materials entering into construction from any firm that cannot furnish a certificate of compliance with the code applying to the manufacture of the materials so supplied. The divisional code authority cites a case wherein a contractor purchased considerable material and incorporated such material in the work without securing the required certificate of compliance. Upon investigation the contractor found that the supplier could not furnish the certificate, and the contractor was unable to collect from the government the cost of the materials.

Increased Activity in Housing Experienced in Buffalo, N. Y.

Among the developments of last week that promise increased activity in housing in Buffalo, N. Y., was the notification received by the Municipal Housing Authority that $5,500,000 has been allocated by the PWA for a low-cost slum elimination housing project. According to local plans, the preliminary proceedings, including the razing of old structures, will be completed by Sept. 1, when the construction of the low-cost dwellings will begin. The slums will be replaced with 1,032 apartments. Henri de Sibour of the PWA housing division has been in Buffalo for some time making a survey of the available architects and contractors and resurveying some of the sites.

A second development was the breaking of ground for a house which will be one of fifty in a $750,000 project for which FHA insured mortgages are contemplated. The homes are being built by Central Park Annex, Inc., of which J. Bennett Wood is president. The houses are being built for sale. The one now under construction will cost $14,000. All the houses will be of two-family type.

No Shortage of Power Capacity Anticipated by Edison Institute

The statistics of the Edison Electric Institute indicate that there is at the present time in this country, as a whole, an excess of 20 per cent, or nearly 6,000,000 kw. of electric generating capacity, over and above that necessary to carry the present load with adequate reserve, according to B. F. Weadock, vice-president and managing director of the institute. Mr. Weadock's statement was made in reply to the statements contained in the first interim report of the National Power Survey made public by the Federal Power Commission last week (*ENR*, April 4, page 498).

The total surpluses as shown by the institute's record do not include plants now being built by the federal government.

L. V. Reese Joins Staff of American Engineering Council

L. V. Reese, who has been handling rural industrial community operations under the rural rehabilitation program of the FERA, has been appointed assistant secretary of American Engineering Council.

In his new position, Mr. Reese will assist the executive secretary, Frederick M. Feiker in carrying out the enlarged program of the American Engineering Council voted at its recent annual meeting as a service agency for relating the organized engineering professions to national affairs in the public interest. He will serve also as a liaison officer between the federal agencies and organized national, state, and local professional engineering societies, by which *222* localities are coordinated.

Mr. Reese will be available both to government agencies and to the member organizations of American Engineering Council, to make effective the engineers' contribution in planning and executing the $4,880,000,000 work relief program, most phases of which involve engineering.

Mr. Reese, who is 43, was educated in civil engineering at the University of Texas and in mechanical, metallurgical, and industrial engineering at Columbia and New York Universities. Prior to his service with federal agencies, he was engaged in the industrial, public utility, and construction fields. During the war, he was assistant supervising constructing quartermaster on cantonment work for the U. S. Army. For several years before the War, he managed his own engineering business.

Railroads Propose Building Approaches to St. Louis Bridge

The most recent development in the attempt to provide additional railroad approaches to the Municipal Bridge at St. Louis is a proposal by the Terminal Railroad Association to build the approaches itself and to be compensated by the city out of toll revenue derived from the use of the bridge by the railroad. Mayor Dickmann is reported to regard the proposal as acceptable to the city. As a part of this proposal, the Association guarantees a minimum of $500,000 toll income annually. The next step in the bridge negotiations would be an application to the Board of Public Service by the Association for a permit to construct the approaches. It is estimated that the necessary approaches can be built for $750,000. The Association has already expended $1,400,000 in erecting two approaches and part of a third.

Mayor Dickmann has also stated that the city may exercise its option, under the agreement with the Association, to lease the upper deck of the Eads Bridge. This would require about $140,000 annually to be taken from the $500,000 income that the city will receive from the railroads for the use of the Municipal Bridge. While the high vehicular toll imposed by the Association will be eliminated, a toll charge commensurate with that on the Municipal Bridge will be retained on the Eads Bridge.

If the plan for the Terminal Railroad Association to build the approaches is carried out, the city will drop its application for a $1,103,000 loan and grant from the government for the work.

SOCIETY CALENDAR

NATIONAL RIVERS AND HARBORS CONGRESS, annual convention, Washington, D. C., May 2 and 3.

AMERICAN WATER WORKS ASSOCIATION, annual convention, Cincinnati, Ohio, May 6-10.

AMERICAN INSTITUTE OF ARCHITECTS, annual convention, Milwaukee, Wis., May 28-30. THE PRODUCERS' COUNCIL will hold its 12th annual meeting in connection with the Institute meeting.

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting, Detroit, June 24-28.

AMERICAN SOCIETY OF CIVIL ENGINEERS, annual convention, Los Angeles, July 3-5.

NEW YORK STATE SOCIETY OF PROFESSIONAL ENGINEERS, annual meeting, New York, May 18, 1935.

NORTHEASTERN SECTION, American Society of Civil Engineers, will hold its meeting May 11 instead of April 13, as previously announced.

BOSTON SOCIETY OF CIVIL ENGINEERS recently elected John B. Babcock, professor of railway engineering, Massachusetts Institute of Technology, Boston, president, Raymond W. Coburn, vice-president and Prof. Albert Haertlein and J. Stuart Crandall, directors; Everett N. Hutchins, secretary, and Karl R. Kennison, treasurer.

BUFFALO SECTION, American Society of Civil Engineers, has elected Arthur P. Skaer, secretary of the contracting firm of Crooker, Carpenter & Skaer, president for the ensuing year. Other officers elected were W. P. Feeley, vice-president and S. S. Neff, secretary.

THE ASPHALT INSTITUTE, at the annual meeting of the board of directors, re-elected B. L. Boye as president. Mr. Boye is head of the asphalt and fuel oil activities of the Socony-Vacuum Oil Co.

Personals

ROBERT P. TRASK has been appointed superintendent of public works at Lexington, Mass., effective April 1. He succeeds WILLIAM S. SCAMMON.

LIEUT.-COMDR. FREDERICK W. HEWES, of the Civil Engineers Corps of the Navy, has been assigned to duty at the Fleet Air Base, Coco Solo, Canal Zone.

CHARLES J. THOMAS, for ten years executive secretary of the Greater Buffalo Advertising Club, Buffalo, N. Y., has accepted an appointment as secretary-manager of the Cleveland Engineering Society.

ARTHUR T. CLARK, for the past six years associated with the Community Water Service in the office of the Supervising Engineer in New York and manager of the Greenwich (Conn.) and Port Chester Water companies, has been appointed chief engineer and manager of the water department of Morristown, N. J.

ARTHUR N. WOODWARD, deputy superintendent of streets, Springfield, Mass., was given a testimonial dinner by his friends and associates in the city service recently. The dinner was in celebration of Mr. Woodward's 47th anniversary of his entry into the department of streets and engineering. He has been deputy superintendent of the department since 1913.

T. O. RUSSELL, consulting engineer of Eugene, Ore., has been appointed chief engineer of the Public Utilities Commission of Oregon. Mr. Russell is a civil engineer with wide experience formerly

with railroads and lately in more diversified lines as a consultant. As chief engineer of the Oregon commission he succeeds Claude R. Lester, who has been retained by the commission for special work in connection with litigation in rate cases still pending.

FREDERICK A. YOUNG, president of the Power Service Corp., Providence, R. I., engineers and architects, has been appointed chief of the division of public utilities of Rhode Island, succeeding the recently removed state public service commission. Mr. Young has been active in power engineering for the past twenty years, and in addition has been in charge of the design and construction of the East Smithfield and Pascoag water systems.

Obituary

WILLIAM HUMMEL, contractor of Cincinnati for many years, died at his home in that city on April 4.

CHARLES MURRAY COTT, vice-president of the Carmichael Construction Co., Akron, Ohio, died on March 31 at the age of 54. Mr. Cott went to Akron from Cleveland in 1918 to joint the Carmichael Co.

HENRY ADOLPH STOCKMAR, pioneer Birmingham contractor and builder, died in that city April 1, after an illness of several weeks. Mr. Stockmar was born in Switzerland and came to Birmingham in 1887. He was a former member of the board of aldermen and had been active in civic affairs for many years. He was 75 years old.

COLONEL MARK BROOKE, U.S.A., retired, died in Washington on April 6 at the age of 58. Born in Columbia, S. C., he was graduated from Haverford College in 1896 and from the U. S. Military College six years later. After service in the engineers corps in Panama and Cuba he became assistant instructor of practical military engineering at West Point. During the World War he commanded the Thirty-Third Regiment of Engineers at Brest, afterwards becoming an instructor at the Command and General Staff School, a member of the general staff, and division engineer for the Gulf at New Orleans. He was retired in 1932.

CONSTRUCTION STATISTICS OF THE WEEK

THE highest private engineering construction awards in more than two years carry this week's engineering construction volume to the highest weekly total since July 19 of last year. The total volume of awards for the week is $45,052,000 of which $20,764,000 is private construction and $24,288,000 represents public works. The federal total is the highest volume reached this year, $9,314,000 while state and municipal work is $14,974,000.

Industrial buildings awards at $10,437,000 are the highest volume since Dec. 20 last year, and commercial buildings, at $8,494,000, are highest since May 31, 1934. Highway awards jumped to $6,974,000 and earthwork, irrigation and waterways to $6,857,000. Public buildings at $7,663,000 are slightly below the high volume reported last week.

The larger awards include among the buildings: refinery for Texas Co., Port Arthur, Tex., $2,500,000; pulp mill for Weyerhauser Timber Co., $4,000,000; steel strip mill for Great Lakes Steel Corp., Ecorse, Mich., $3,000,000; Beach Garden Apartments, Brooklyn, N. Y., $6,500,000; museum building at Fort Tryon Park, Metropolitan Museum of Art, New York, N. Y., $2,500,000; air conditioning, Dept. of Interior Bldg., Washington, D. C., $1,022,000; and fifty 2-family houses, to be financed by the FHA, Buffalo, N. Y., $750,000.

Highway lettings include $683,000 by Illinois; $546,000 by Indiana; $600,000, force account by Riverside County, Calif., portion of Banning-Idyllwild Highway, and $698,000, part of city labor and part by contract, for street construction and maintenance, Newton, Mass.

Federal government engineers awarded the dredging of Lake Mongoulois Channel, Louisiana, $588,000; the Mohawk Dam, Warsaw, Ohio, $1,721,000 and spillway gate structure at Fort Peck Dam, Mont., $3,985,000.

At Omaha, Neb., the Union Pacific Railway System placed an order for 19,500 tons of rails estimated to cost $1,400,000.

New capital for the week consists solely of $5,889,000 in state and municipal bond sales.

CONTRACTS

(Thousands of Dollars)

	Weekly Average Apr. 1934	Prev. 4 Weeks	Week Apr. 11 1935
Federal Government	$6,389	$3,578	$9,314
State and municipal	15,432	15,262	14,974
Total public	$21,821	$18,840	$24,288
Total private	4,781	4,489	20,764
Week's total	$26,602	$23,329	$45,052
Cumulative to date:			
1934	$430,005,000	1935	$377,519,000

NEW PRODUCTIVE CAPITAL

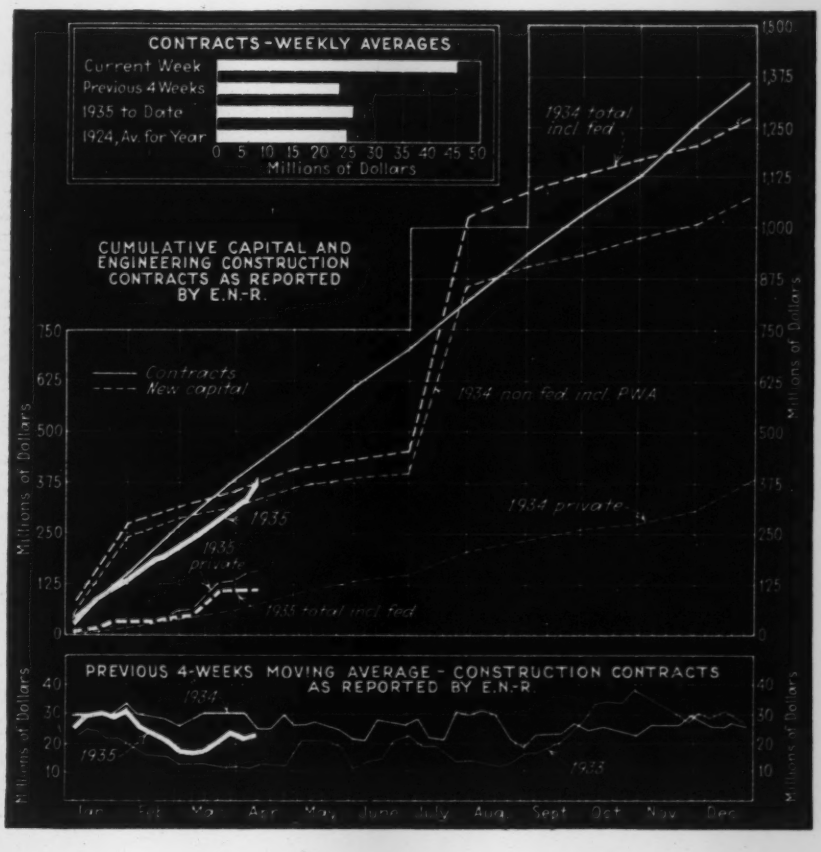
(Thousands of Dollars)

1935	Week Apr. 11	Cumulative
State and municipal	$5,889	$131,629
PWA allotments, S&M	....	—44,950
RFC loans, S&M	....	84
Corporate issues	....	....
PWA allotments, private	....	7,129
Total, Non-Federal	$5,889	$93,892
PWA allotments, Federal Constr.	.....	7,336
Total new capital	$5,889	$101,228
Cumulative to date:		
1934	$387,479,000	1935	$101,228,000

Note: These figures include private bonds, and stocks sold for productive purposes; state and municipal bonds for construction; PWA loans and grants to states and municipalities, including the special highway funds; PWA private loans, and allotments for Federal construction. Negative amounts in PWA totals indicate excess of rescissions and reductions over reallotments and increases in outstanding allotments.

INDEX NUMBER

E.N.R.-Cost	1913 = 100	1926 = 100	E.N.R.-Volume	1913 = 100	1926 = 100
Apr., 1935	194.50	93.49	Mar., 1935	101	44
Mar., 1935	194.26	93.38	Feb., 1935	76	33
Apr., 1934	195.86	93.90	Mar., 1934	116	51
1934 (Av.)	198.10	95.23	1934 (Av.)	114	50
1933 (Av.)	170.18	81.80	1933 (Av.)	102	47
1932 (Av.)	156.97	75.45	1932 (Av.)	127	56


CONTRACTS - WEEKLY AVERAGES
Current Week
Previous 4 Weeks
1935 to Date
1924, Av. for Year
0 5 10 15 20 25 30 35 40 45 50
Millions of Dollars
CUMULATIVE CAPITAL AND ENGINEERING CONSTRUCTION CONTRACTS AS REPORTED BY E.N.-R.
Contracts
New capital
1934 total incl. fed
1934 non fed. incl. PWA
1934 private
1935
1935 private
1935 total incl. fed
Millions of Dollars
PREVIOUS 4-WEEKS MOVING AVERAGE - CONSTRUCTION CONTRACTS AS REPORTED BY E.N.-R.
1934
1935
1933
Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec

Current Construction Unit Prices

Pile Dikes and Revetments, Missouri River

CONSTRUCTION of dikes and revetments forming part of the Missouri River improvement program from Kansas City to Sioux City, at Indian Cave and Cottier Bends, was started in September, 1934, with completion scheduled for one year after contract award. The work consists of approximately 50,470 lin.ft. of standard pile dikes and 13,710 lin.ft. of revetment. The dikes are formed in two and three pile clumps spaced 15 and 18 ft. on centers, with minimum pile diameters of 7½ to 9 in. at the tip and 13½ to 14½ in. within 3 ft. of the butt. The work is under the jurisdiction of the U. S. Army Engineers at Kansas City. The following tabulation gives unit prices and totals for the three low bidders. (A) Woods Bros. Construction Co., Lincoln, Neb. (contract) $1,659,410; (B) Kansas City Bridge Co., Kansas City, $1,672,256; (C) Bilhorn, Bower & Peters, Inc., St. Louis, $1,758,877.

DIKES AND REVETMENTS, MISSOURI RIVER

Item	Bidder A	Bidder B	Bidder C
Pile dike items:			
1. Lumber mattress—43,180 squares	$9.00	$9.00	$9.25
2. Stone on mattress and in dike—60,500 cu.yd	3.75	4.00	4.50
3. Stone in paving—4,400 cu.yd	5.50	6.00	5.50
4. Piles, stringers and brace piles for pile clump and pile clump brace dike and single pile dikes—1,247,000 l.f	0.58	0.58	0.60
Revetment items			
1. Lumber mattress—11,790 squares	8.80	9.00	9.25
2. Stone on Lumber mattress—13,000 cu.yd	3.70	4.00	4.50
3. Stone in paving—16,200 cu.yd	5.50	6.00	5.50
4. Anchor piles (lumber mattress)—9,300 l.f	0.55	0.58	0.55
5. Piles and stringers—88,400 l.f	0.57	0.58	0.60

Hetch Hetchy Reservoir Extension

RAISING the crest of the O'Shaughnessy dam 85½ ft. to increase the Hetch Hetchy Reservoir capacity is under way, contract for the work being awarded by the San Francisco Public Utilities Commission in the latter part of January, 1935. The dam is located at the west end of the Hetch Hetchy valley on the Tuolumne River and the new construction is to be partly financed by Federal funds with PWA minimum wage rates prevailing. Unit prices and totals of the three low bids, with quantities, follow for comparison. (A) Trans-Bay Construction Co., San Francisco (contract) $3,219,965; (B) Utah Construction Co., W. A. Bechtel Co., and Henry J. Kaiser Co., San Francisco, $3,447,598; (C) Southwestern Contracting Group, Inc., Los Angeles, $3,485,485.

RAISING O'SHAUGHNESSY DAM

Item	Bidder A	Bidder B	Bidder C
1. Clear reservoir site—385 acres	$160.00	$300.00	$120.00
2. Excavate dam foundations—30,000 cu.yd	2.75	4.00	3.65
3. Excavate spillway—28,000 cu.yd	1.80	1.95	2.50
4. Excavate, roads & misc.—8,000 cu.yd	.50	.60	1.10
5. Excavate, roads & misc., solid rock—21,000 cu.yd	1.40	1.50	1.10
5a. Tunnel excavation—3,600 cu.yd	8.00	8.40	6.25
6. Excavate trails, earth—500 cu.yd	1.00	1.20	1.50
7. Excavate trails, rock—500 cu.yd	4.00	3.00	3.00
8. Excavate concrete, existing dam—1,000 cu.yd	5.00	14.40	14.00
9. Roughen surface existing dam—37,000 sq.ft.	.11	.12	.09
10. Roughen surface, siphon spillway conduits, downstream surface of dam over conduits—55,000 sq.ft	.11	.18	.20
11. Remove concrete struct. existing dam—175 cu.yd	6.00	18.00	12.00
12. Drill grout holes for dam and spillway, under 30 ft.—3,000 l.f	.85	1.15	.75
13. Drill grout holes for dam and spillway, over 30 ft.—1,750 l.f	2.50	2.40	2.00
14. Drill drainage holes in fdt. for dam, under 30 ft.—700 l.f	2.20	2.00	2.75
15. Drill drainage holes in fdt. for dam, over 30 ft. deep—700 l.f	2.75	3.50	2.75
16. Drill grout holes, dam face—150 l.f	2.50	1.70	2.00
17. Drill grout holes, dam galleries—150 l.f	3.00	2.30	2.00
18. Drill grout holes, dam inspection wells—120 l.f	3.50	2.30	2.00
19. Drill holes for anchor bars, etc. in place—25,000 l.f	.55	1.15	.45
20. Caulk joints in concrete—4,400 l.f	.60	1.30	.90
21. Connect grout holes, dam fdt. to existing dam face—230, each	3.00	2.30	2.75
22. Connect grout pipes in existing dam galleries—30, each	4.00	3.00	3.80
23. Connect grout pipes in inspection wells—60, each	5.00	3.00	3.80
24. Pressure grout—7,500 cu.ft	1.20	1.30	1.10
25. Concrete, mass in dam—205,000 cu.yd	4.80	5.80	4.34
26. Concrete, impervious dam surfaces—32,000 cu.yd	4.80	5.90	4.34
27. Concrete, dam slots—17,000 cu.yd	4.80	5.90	4.20
28. Concrete, plug siphon spillways—3,700 cu.yd	4.80	8.00	3.50
29. Concrete, spillway & bridge weir—6,300 cu.yd	7.25	10.00	10.50
30. Concrete, valve house, screen rack, etc.—1,000 cu.yd	18.00	17.00	32.00
31. Concrete, railings—150 cu.yd	46.00	30.00	60.00
32. Concrete, precast, stairways—50 cu.yd	31.00	21.00	50.00
33. Concrete, spillway lining, downstream end—1,500 cu.yd	9.00	10.50	16.50
34. Concrete, precast, screen racks—16 cu.yd	75.00	48.00	90.00
35. Concrete blocks, dense precast—600 cu.yd	19.00	12.00	14.00
36. Concrete blocks, precast porous—850 cu.yd	17.00	12.00	10.00
37. Masony drainage holes—350 l.f	.70	1.70	1.10
38. Cement gun mortar coating, ¾-in.—10,000 sq.ft	.11	.10	.28
39. Portland cement—277,000 bbl	4.60	3.90	3.85
40. Reinforcing steel—450,000 lb	.055	.06	.05
41. Anchor bars—400,000 lb	.05	.05	.005
42. Rubble masony walls—100 cu.yd	10.05	10.00	16.50
43. Masonry guard rails—100 cu.yd	12.00	14.00	16.50
44. Dry masony walls—500 cu.yd	5.50	7.00	8.00
45. Wrought steel pipe, furnish & replace, ½-in.—500 l.f	.11	.13	.11
46. Metal tubing, furnish & place, ½-in.—14,000 l.f	.07	.13	.11
47. Wrought steel pipe, furnish & place, 1 in.—2,000 l.f	.17	.16	.17
48. Metal tubing, furnish and place, 1 in.—300,000 l.f	.12	.13	.12
49. Wrought steel pipe, furnish & place, 1¼ in.—5,000 l.f	.23	.22	.25
50. Metal tubing, furnish & place, 1¼ in.—27,000 l.f	.18	.20	.16
51. Wrought steel pipe, furnish & place, 2-in.—1,000 l.f	.30	.32	.33
52. Wrought steel pipe, furnish & place, 2 to 8 in.—125,000 lb	.08	.11	.08
53. Wrought steel pipe fittings, furnish & place, under 8 in.—10,000 lb	.20	.35	.16
54. Metal tubing fittings, furnish & place, under 1¼ in.—18,000 lb	.70	.67	.65
55. Gate valves, 1 in. furnish & place—400, each	1.45	1.45	1.10
56. Gate valves, 1¼ in. furnish & place—200 each	2.30	2.30	2.20
57. Gate valves, 2 in. furnish & place—100, each	3.25	3.50	3.30
58. Gate valves, 2 to 8 in. furnish & place—2,500 lb	.35	.27	.22
59. Remove & reinstall pipe & fittings—10,000 lb.	.065	.17	.05
60. Header to cooling coil connections—3,200 each	.85	2.00	1.10
61. Grout pipe outlets—6,000, each	.35	.28	.55
62. Electrical, metal conduits, furnish & install—1,500 lb	.25	.28	.40
63. Galv. pipe hand railing—13,300 lb	.20	.20	.22
64. Copper water stops—18,500 lb	.45	.24	.50
65. Sheet metal grout stops—50,000 lb	.14	.15	.22
66. Corrugated metal drains—50,000 lb	.12	.13	.12
67. Stairs, ladders, gratings—55,000 lb	.16	.15	.13
68. Misc. steel work—1,000 lb	.25	.25	.33
69. Cast iron gratings—5,000 lb	.14	.15	.08
70. Misc. brass & bronze—4,000 lb	.55	.50	.45
71. Galvanizing—50,000 lb	.04	.05	.02
72. Remove & reinstall misc. equip. from old to new location—5,000 lb	.08	.17	.13
73. Remove & reinstall water stage recorder—lump sum	600.00	1,200.00	1,100.00
74. Remove & reinstall accumulators, frames, etc.—lump sum	1,100.00	1,400.00	1,650.00
75. Remove & reinstall three 36-in. balanced valves—lump sun	1,100.00	4,000.00	2,750.00
76. Install 3 42-in. steel pipe connections to balanced valves—50,000 lb	.027	.02	.017
77. Install outlet valves (furnished by city)—500,000 lb	.02	.03	.017
78. Install fixed supports, pier plates, hinge pins for spillway gates—110,000 lb	.027	.02	.033
79. Install drum gates & seals—250,000 lb	.018	.02	.033
80. Install spillway gate fittings—100,000 lb	.03	.04	.033
81. Install spillway gate control mechanism—35,000 lb	.09	.05	.06
82. Install misc. metal work (furnished by city)—2,000 lb	.11	.10	.11
83. Paint concrete surfaces in waterways—3,500 sq.ft	.22	.10	.16
84. Roofing on concrete houses—7 squares	65.00	50.00	55.00
85. Crusher run base—800 cu.yd	2.50	2.50	3.30
86. Emulsified asphalt—5,000 gal	.20	.12	.11
87. Base rock—110 cu.yd	2.50	3.00	5.00
88. Screenings—60 cu.yd	3.00	3.00	8.80
89. Corrugated metal pipe culverts—3,200 lb	.15	.10	.16
90. Drain tile, 6 in.—500 l.f	.65	.70	.65
91. Cooling plant, furnish & install—lump sum	25,000.00	20,000.00	25,000.00
92. Operate refrigerating plant—7,200 hr	3.00	2.90	2.25

Highway Bridge at Ebey Slough, Wash.

CONSTRUCTION of a combined concrete, steel and timber trestle bridge, 6,734 ft. in length over Ebey Slough on State Highway 15 in Snohomish Co., Wash., started in February, 1935, forming another link in the state's extensive highway developments financed through PWA funds. The project consists of one 240-ft. steel truss span, six 35-ft. concrete approach spans, 307 19-ft. treated timber trestle spans with concrete decks, and 448-ft. of untreated timber trestle. Twelve bids ranged from $306,129 to $352,119. The following tabulations compare the unit bids and totals of the three low bidders. (A) West Coast Construction Co., Seattle, (contract) $306,129; (B) Puget Sound Bridge & Dredging Co., Seattle, $309,689; (C) General Construction Co., Seattle, $310,492.

240 FT. STEEL SPAN BRIDGE, WASHINGTON

	A	B	C
1. Structure excavation—2,320 cu.yd.	$5.25	$8.00	$9.00
2. Concrete, CL. A.—3,940 cu.yd.	17.50	16.00	17.00
3. Concrete, CL. B.—300 cu.yd.	17.00	14.00	15.00
4. Concrete, CL. C.—250 cu.yd.	23.00	14.00	15.00
5. Concrete, CL. D.—270 cu.yd.	23.00	10.00	13.00
6. Steel reinforcing—684,000 lb.	.04	.04	.04
7. Structural steel—455,000 lb.	.058	.06	.06
8. Cast steel—3,700 lb.	.12	.15	.12
9. Steel drainage castings—12 each.	20.00	25.00	30.00
10. Steel handrail—12,062 lin.ft.	1.14	1.00	1.00
11. Bronze expansion plates—360 lb.	.53	.50	.60
12. Timber & plank—183 M.B.M.	40.00	35.00	38.00
13. Timber & plank, zinc chloride treated—38 M.B.M.	52.00	60.00	64.00
14. Timber & plank, creosoted—1,071 M.B.M.	57.50	64.00	60.00
15. Piling, furnished only—72,450 l.f.	.18	.11	.13
16. Piling, creosoted—28,075 l.f.	.50	.60	.54
17. Piling, mineralized cell—6,700 l.f.	.35	.35	.38
18. Drive piles—1,667, each.	5.50	9.00	9.00
19. Pile splices—1,276, each.	9.50	10.00	10.00
20. Test piles—10, each.	100.00	50.00	35.00
21. Signs and reflectors—lump sum	55.00	75.00	100.00
22. Gravel backfill—150 cu.yd.	3.00	2.50	4.00
23. Remove existing structure—lump sum	3,000.00	5,000.00	2,500.00
24. Remove existing pavement—50 sq.yd.	5.00	1.00	1.00
ROADWAY CONSTRUCTION:			
25. Clear and grub—lump sum	2,000.00	750.00	500.00
26. Excavate & haul, unclassified—4,450 cu.yd.	.50	.65	.40
27. Structure excavation—260 cu.yd.	1.25	1.00	1.00
28. Excavation, Class D—60 cu.yd.	1.00	.80	1.00
29. Special borrow, in place—2,490 cu.yd.	.50	.30	.40
30. Gravel borrow, misc.—990 cu.yd.	.50	.85	.80
31. Slope treatment—640 lin.ft.	.15	.15	.10
32. Screened gravel surfacing, one course—140 cu.yd.	2.75	2.50	2.00
33. Crushed stone std. surface, top—30 cu.yd.	3.50	3.00	4.00
34. Crushed stone std. base course—90 cu.yd.	3.50	3.00	4.00
35. Finish shoulders and ditches—528 l.f. roadway	.25	.12	.10
36. Cem. Concrete pavement, full width—388 sq.yd.	2.30	2.25	2.30
37. Cem. Concrete pavement, half width (10x7x10 in.) H.E.S.—429 sq.yd.	2.75	2.50	2.30
38. Reinforcing, pavement, type No. 2—7,460 lb.	.05	.05	.05
39. Dowel bars and caps—161 each.	.25	.25	.20
40. Dowell bars, only—383 each.	.20	.18	.15
41. Heavy service curb guard—40 lin.ft.	.55	.60	1.00
42. Asphalt conc. pav't Ch. B. (wearing course)—16 tons	9.50	9.00	11.00
43. Asphalt conc. pav't Cl. E, base course—42 tons	9.50	9.00	11.00
44. Cable guard rail, Design No. 6—470 lin.ft.	.68	.80	.80
45. Concrete, Cl. C—100 cu.yd.	30.00	30.00	20.00
46. Special concrete C. B. with C. I. cover etc.—2 each	50.00	60.00	60.00
47. Remove present concrete paving—596 sq.yd.	.40	.25	.50
48. Remove present wood guard rail—100 lin.ft.	.25	.10	.20
49. Remove and store present asphalt surfacing—150 sq.yd.	.30	.25	.40
50. Relay 12 in. conc. pipe—42 lin.ft.	.75	.25	.50
51. Galv. Iron waterpipe ¾-in. diam. in place—218 l.f.	.50	.25	.15
52. Plain or V. concrete. waterpipe, 6 in. diam.—95 l.f.	.75	.30	.40
53. Plain or V. concrete waterpipe, 12-in. diameter—153 l.f.	1.00	.85	1.00
54. Std. reinforced concrete pipe, 18-in. diam.—57 l.f.	2.00	2.00	2.50
55. Std. reinforced concrete pipe, 24-in. diam.—123 l.f.	3.75	2.75	3.50
56. Accelerate embankment subsidence, force acct.—estimated	1,000.00	1,000.00	1,000.00

San Francisco Bay Pipe Line Crossing

BIDS were received in March, 1935, on two alternative propositions for the construction of a double line of 54-in. diameter submarine pipe line across the southerly arm of San Francisco Bay at Dumbarton Strait. The proposed line, 2,800 ft. in length, starts from a point located on the east shore about 3½ miles west of the town of Newark and extends to the existing caisson of the water department's steel bridge located 7 miles east of Redwood City. Also included is a 435-ft. stretch of single pipe extending across the navigable Newark Slough at a point about 2 miles west of Newark. Three alternative propositions were scheduled: (A) pipe with flange joints supported on submarine pile trestles; pipe to be of ¾-in. steel plate coated outside with bituminous enamel and a jacket of 6-in. reinforced gunite. Inside of pipe to be coated with a spun bituminous enamel lining, with lengths of pipe optional and jointed with flanges bolted up under water and encased in tremie concrete blocks. The pile trestle is to be composed of bents on 20 ft. centers in trenches dredged for the purpose and later backfilled. (B) Cast iron pipe coated inside and out with bituminous enamel and having special flexible joints. Pipe walls are to be 2½-in. thick and laid in minimum 12-ft. lengths within dredged trenches and on crushed rock fill, all to be back filled. (C) Pipe to consist of a flexible joint steel cylinder concrete pipe, steel of ¾-in. thickness with an exterior 4 in. bituminous concrete jacket. Interior is to be lined with a 2 in. layer of centrifugally spun concrete. Minimum pipe length is to be 12 ft. and laying and excavating is required as outlined in Proposition B. Five bids were received on Proposition A ranging from $717,795 to $987,324; one on Proposition B of $928,535; and none on Proposition C. Following is a comparison of quantities and unit prices for the low bids on A and B as submitted by Merritt-Chapman & Scott Corporation, San Francisco, with respective totals of $717,795 and $928,535.

BAY CROSSING PIPE LINE—SAN FRANCISCO

	Quantities		Low Bids	
	Prop. A	Prop. B	Prop. A	Prop. B
1. Excavation, shore line to Dumbarton Strait—cu.yd.	100,000	118,000	$0.33	$0.50
2. Excavation, shore line to Newark slough—cu.yd.	6,000	7,000	.75	.80
3. Excavation on land—cu.yd.	100	100	3.00	3.00
4. Rock fill—cu.yd	530	24,500	9.00	5.00
5. Furnish untreated piles—lin.ft	800	500	.50	.50
6. Furnish treated piles—lin.ft.	52,000	11,500	.60	.80
7. Driving piles—each	880	200	45.00	50.00
8. Furnish and install untreated timber—M.B.M.	10	5	250.00	250.00
9. Furnish and install treated timber—M.B.M.	70	20	550.00	500.00
10. Tremie concrete, Class A—cu.yd.	1,425	130	40.00	50.00
11. Tremie concrete, Class B—cu.yd.	25	525	40.00	46.00
12. Extra cement—per bbl.	125	50	5.00	5.00
13. Remove existing 16-in. submarine pipes in channel of Dumbarton strait—lin.ft.	2,600	2,600	2.50	2.50
14. Remove existing 16-in. submarine pipes between east and west shore lines—lin.ft.	12,000	12,000	1.10	1.10
15. Furnish and lay 54-in. flanged joint steel pipe with gunite jacket in Dumbarton Strait—lin.ft.	5,600	.....	73.00	.....
16. Furnish and lay 54-in. flanged joint steel pipe with gunite jacket in Newark Slough—lin.ft	435	.....	73.00	.....
17. Construct angles in 54-in. flanged joint pipe line—each	28	.....	120.00	.....
18. Furnish and lay 54-in. flexible joint cast iron pipe in Dumbarton Strait—lin.ft.	.....	5,600	.....	102.00
19. Furnish and lay 54-in. flexible joint cast iron pipe in Newark Slough—lin.ft.	.....	435	.....	110.00
20. Structural steel substructure lb.	20,000	20,000	.14	.14
21. Furnish and install steel pipe, tapers, castings	lump sum	lump sum	12,085.00	12,085.00
22. Install gate valves & operating mechanisms—(material furnished by city)	lump sum	lump sum	2,000.00	2,000.00
23. Furnish and install valves, fittings, auxiliary piping for water motors and ejector	lump sum	lump sum	9,000.00	9,000.00
24. Power plant and electrical installation	lump sum	lump sum	2,000.00	2,000.00
25. Construct superstructure.	lump sum	lump sum	7,500.00	7,500.00
26. Furnish and install travelling crane and hoist	lump sum	lump sum	1,500.00	1,500.00
27. Steel floor grating—sq.ft.	1,600	1,600	1.50	1.50
28. Furnish and install steel stairway and hand railings	lump sum	lump sum	1,500.00	1,500.00

Construction Equipment and Materials

Hydraulic Testing Machine For Plastic Mortar Tests

A new 75,000-lb. hydraulic compression testing machine, designed to meet the requirements of the working committee on plastic mortar tests of the A.S.T.M., has been developed by the Baldwin-Southwark Corp., Philadelphia, Pa. It is suited particularly for 2x2-in. plastic mortar cubes, 2x4-in. cement cylinders, and 3x6-in. concrete cylinders.

The machine is featured by a weighing system separate from the hydraulic loading system. The rotating disk type of load-rate control is employed. An individual telechron timing motor is mounted on the rear of each of the two styles to operate the pacing disk. In its normal arrangement the pacing disk operates at 4,000 lb. per sq.in. per min.

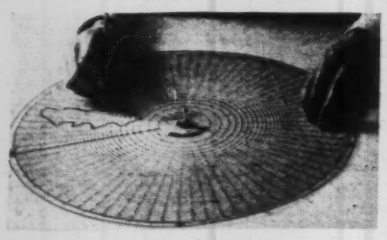
New Area-Measuring Device A Transparent Disk

A new area-measuring device, called the Rotometer, has been developed by Aerial Explorations, Inc., New York, N. Y. It was originally designed to measure the areas of mosaic maps, where the joint lines prohibited the use of a planimeter. In its present finished form, the instrument may be applied to any area-measuring task on any kind of surfacing.

It consists of a transparent disk, made from a special acetate stock that has uniform shrinkage. On the disk is inscribed a series of concentric circles spreading out to a margin which is calibrated on the standard model, in square inches, and on special models, in any desired unit of area measurements.

The disk is placed over the map or drawing so that the area to be measured lies with its inner and outer boundaries approximately halfway between any two adjacent circles. A pencil mark or pin prick is made at the point where the zero of the outer scale chances to fall. Then, using a pointed instrument, pin or needle, placed at the intersection of the inner boundary of the area and the rotometer circle, the disk is rotated counter-clockwise until another boundary and circle intersection is reached. This procedure is repeated with the successive circles until the entire area is covered, when the graduation on the scale opposite the mark made at the starting point is read. This outer scale can be read directly to hundredths of a graduation.

The Rotometer, for measuring areas



The theory of the instrument is based on the strip method of area determination, each circle representing the center line of a narrow strip which in full circumference measures, on the standard disk, 5 sq.in.

The rotometer is made in four sizes: 7 in. diameter, 1 sq.in. per revolution; 11 in. diameter, 2 sq.in.; 17 in. diameter, 5 sq.in.; large size, 200 sq.in.

New Road Hog Grader

W. A. Riddell Co., Bucyrus, Ohio, announces the new Warco rear-controlled Model 35 road hog grader. The grader is made in two sizes and is so constructed that all standard makes of tractors may be used. The frame is of welded steel construction with five cross-braces of tubular and box sections. All connections are hardened ball joints with machined adjustable bearings.

A two-speed variable-control power lift is used. This new power control assembly is grease-tight, with drop-forged, machined and hardened gears and clutches.

The cab is a large turret top cab with adjustable upholstered seat. The grader has a 54-gal. gasoline tank mounted at the rear of the cab.

New Publications

CALYX CORE DRILLS, Ingersoll-Rand Co., Phillipsburg, N. J., 8½x11, 48 pages.

1935 PICTORIAL REFERENCE CATALOG, Austin-Western Road Machinery Co., Aurora, Ill. 8½x11, 32 pages.

MURRAY STEEL AND BOILER TUBES, 4½x8, 56 pages. Warehouse Stock List.

WORTHINGTON CENTRIFUGAL PUMPS, Worthington Pump & Machinery Corp., Harrison, N. J., 8½x11, 4 pages.

DOMESTIC SELF PRIMING CENTRIFUGAL PUMPS, Domestic Engine & Pump Co., Shippensburg, Pa. 8½x11, 8 pages.

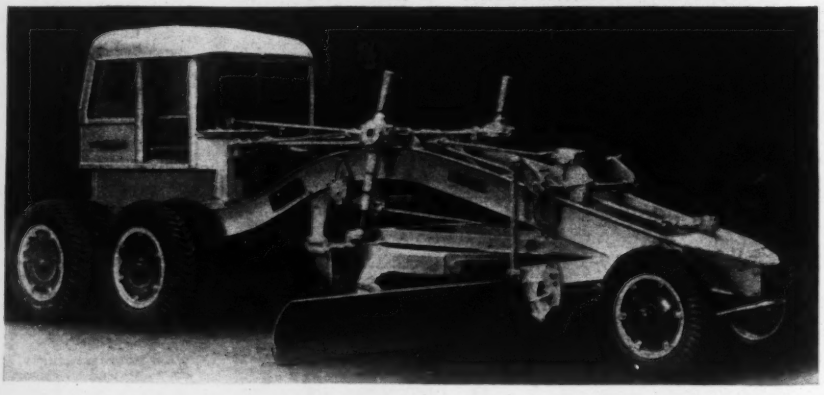
MODERN REBUILT AND GUARANTEED MACHINERY, California Equipment Co., Los Angeles, Calif. 8½x11, 36 pages. Catalog 114, construction, mining and industrial machinery.

ELECTRIC EQUIPMENT FOR POWER SHOVELS, General Electric Co., Schenectady, N. Y. 8½ x11, 20 pages.

CATERPILLAR TERRACERS, Caterpillar Tractor Co., Peoria, Ill. 8½x11, 32 pages.

SIMPLEX JACK, *Templeton*, Kenley & Co., Ltd., Chicago, Ill. 3½x6, 40 pages.

Warco rear-controlled Model 35 road hog grader



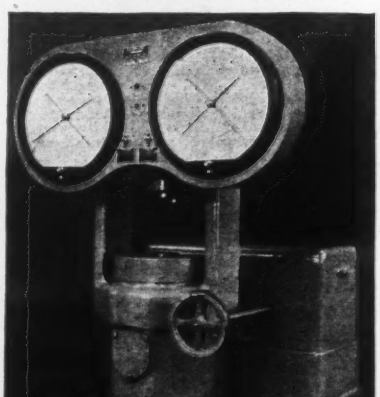
New Equipment in Brief

Waterproofing. A new colorless transparent liquid waterproofing has been announced by the Protexall Co., Philadelphia, Pa. The manufacturer states that the material can be used either inside or outside of buildings, that it is acid-resistant, and that it can be used on wood, brick, stucco, cement, concrete, stone or iron.

Seal Plug. The Multi-Seal Mfg. Co., Chicago, Ill., announces the new multi-seal rivet and anchor bolt to repair holes in metal storage tanks. It is constructed of a ductile composition which expands as a nut is drawn down and a ferrule fans out, compressing a metal head on the inside of the container.

Shovel-Crane-Dragline. American Hoist & Derrick Co., St. Paul, Minn., announces the new "American Gopher" model 350, ½-yard crawler-type shovel-crane-dragline, for gasoline, electric or diesel operation. The machine is featured by the use of splined shafts, anti-friction bearings and independent chain crowd. It has a high operating speed and is quickly convertible from shovel to crane.

Business Notes

To celebrate their 50th anniversary, the Hastings Pavement Co., New York, N. Y., held a luncheon meeting on March 29. A feature of the meeting was the number of men among the 38 guests who represented companies with whom the Hastings Pavement Co. had been doing business for many years, in some cases for the entire 50 years of the company's existence. Among the guests were representatives of R. P. Dorland Co., American Surety Co., N. Y. Trap Rock Co., Standard Oil Co. of N. J., Cleary Brothers, and *Engineering News-Record*.

Baldwin-Southwark's new 75,000-lb. hydraulic compression testing machine